

PROJECTS THEORY APPLICATIONS CIRCUITS TECHNOLOGY

NUTS AND VOLTS

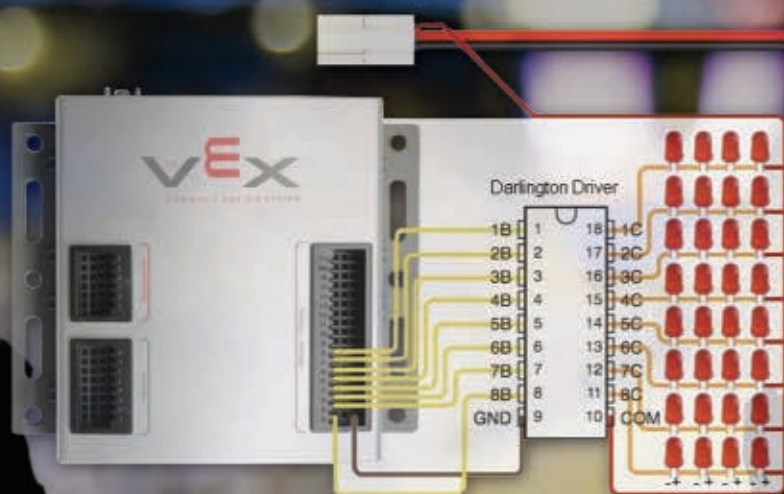
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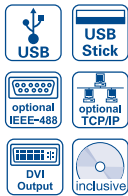
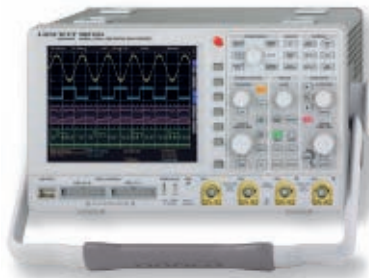
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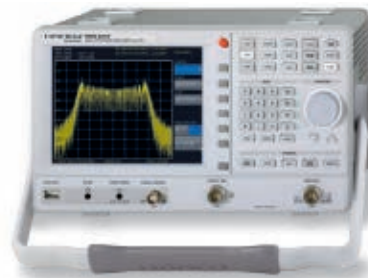
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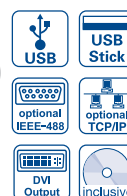


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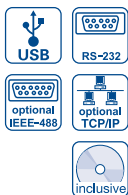


1GHz:
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HMS1010



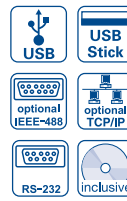
- ✓ Frequency range 100 kHz...3 GHz
- ✓ Amplitude measurement range -114...+20 dBm
- DANL -135dBm with Preamp. Option H03011
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- ✓ Resolution bandwidth 100 Hz...1 MHz in 1-3 steps, 200 kHz (-3 dB) additional 200 Hz, 9 kHz, 120 kHz, 1 MHz (-6 dB)
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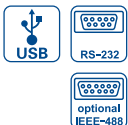


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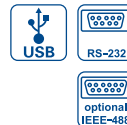


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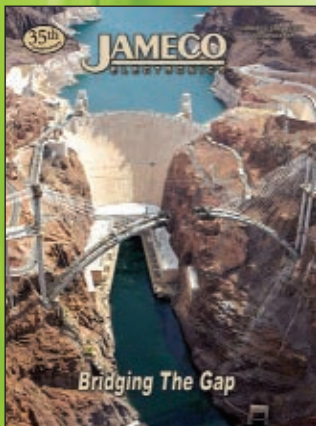
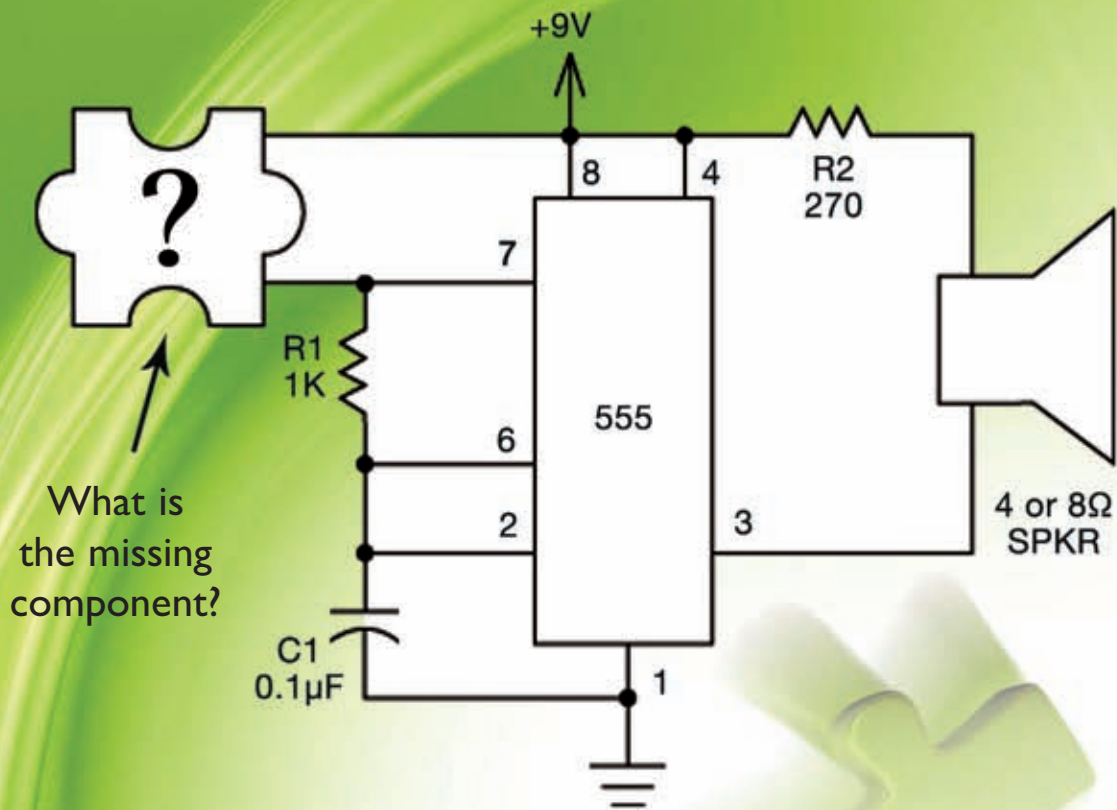
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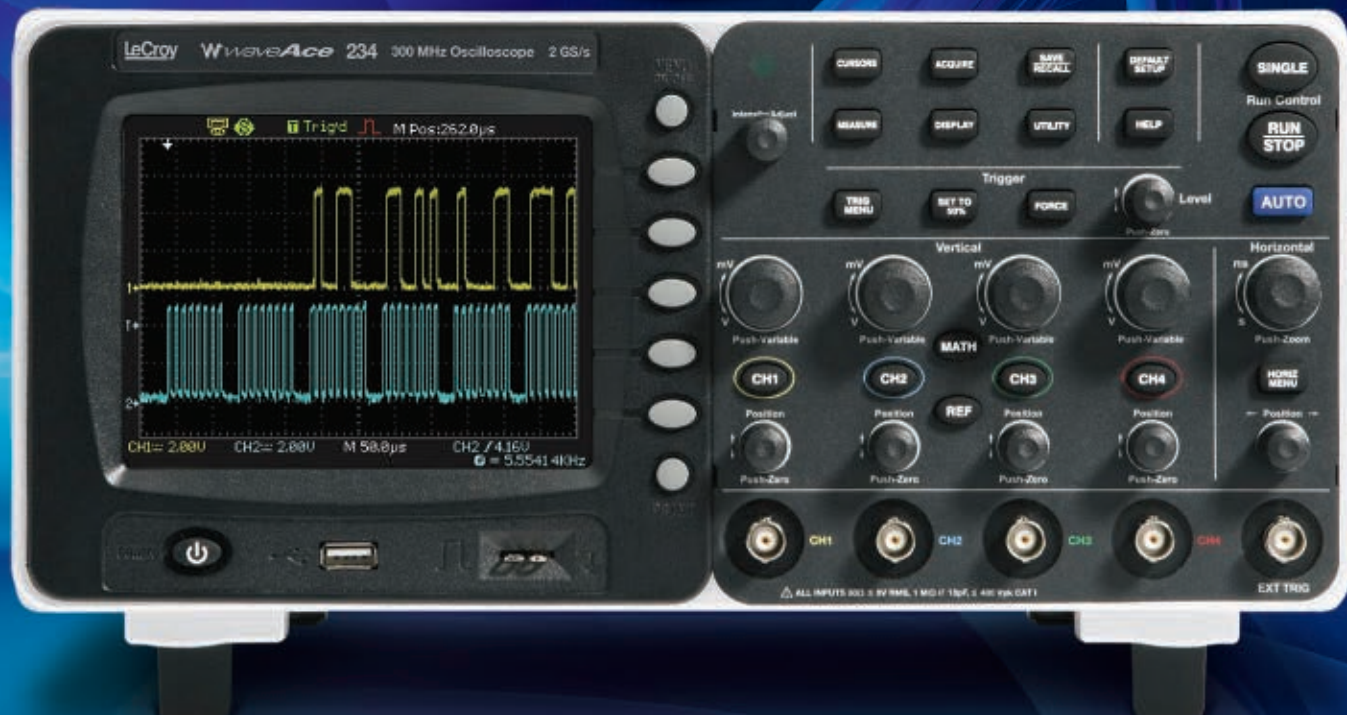
Amateur electronic musician Joe Rhythm is planning a one-man video concert that he plans to post on YouTube. Controlling his array of instruments requires both hands and he wants to build a pressure-sensitive tone generator that he can control with a free finger or even an elbow or foot. Joe quickly whipped up a simple tone generator using parts from his bench stock. Since, there wasn't enough time to order a pressure sensor, he improvised by making one from materials he had on hand. What did he use? Go to www.jameco.com/search6 to see if you are correct and while you are there, sign-up for our free full-color catalog.

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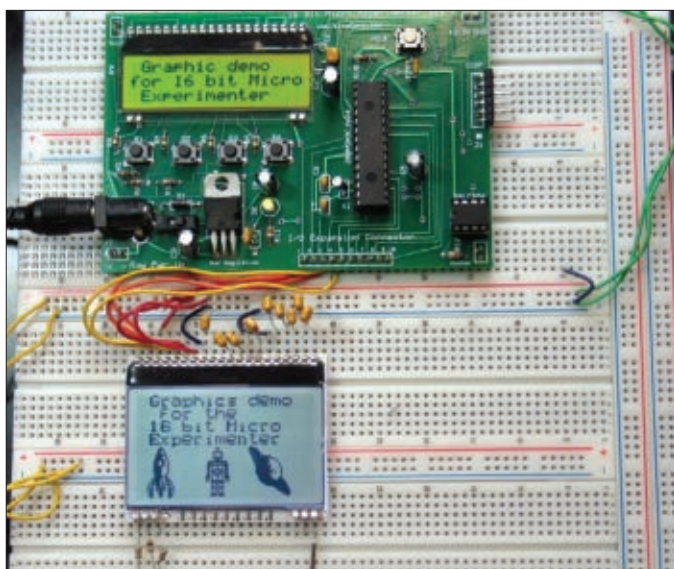
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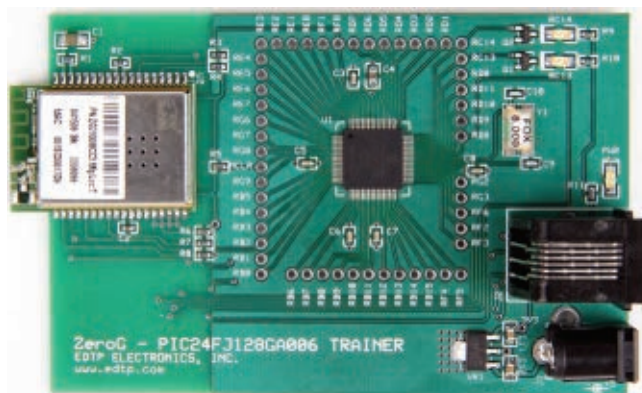
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by Bryan Bergeron, Editor

DEVELOPING PERSPECTIVES

Robotic Pet Teardown

One of the revelations of the post holiday shopping season was that Zhu Zhu™ Pets (www.zhuzhu pets.com) made the most wanted list for many children. The robotic, chatty hamsters that scurry about are essentially carpet roamer robots on steroids. I assume that the draw of these toys is the semi-realistic hamster fur coat, the large library of sounds and phrases they emit when active, and the semi-autonomous activity they exhibit inside the various dedicated Zhu Zhu environments.

As soon as Christmas passed, I ordered one of the pets for \$19 on Amazon — a 50% savings from pre-Christmas prices. The teardown — shown here in **Figures 1-8** — was trivial compared to the task of extracting the toy from the theft-proof packaging. It revealed a clean,

modular design, relatively well planned circuit board (only two wire jumpers), and excellent attention to the user interface. If you're interested in peeking inside your own Zhu Zhu, all you'll need for the operation is a small Phillip's head screwdriver.

Figure 1 shows the life-sized robot hamster intact and upright. You can just make out the momentary contact button embedded in the nose. The buttons accessed through the head and rear are less obvious. **Figure 2** shows the underside of the robot, with the front of the robot to the right. Note the moveable studs to either side of the fixed, center stud on the far right side of the figure. The robot uses these two switches — referred to as data readers by the manufacturer — to detect patterns in the floors of the various Zhu Zhu environments. Depending on the pattern, the robot might move ahead a few inches and then go to sleep, for example.

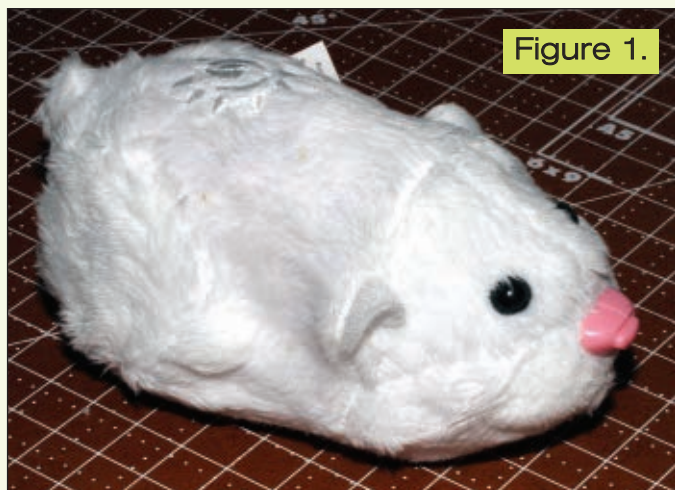


Figure 1.



Figure 2.

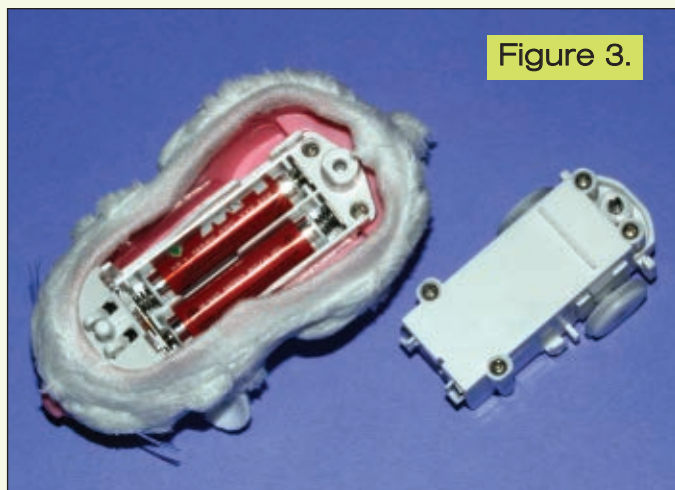


Figure 3.

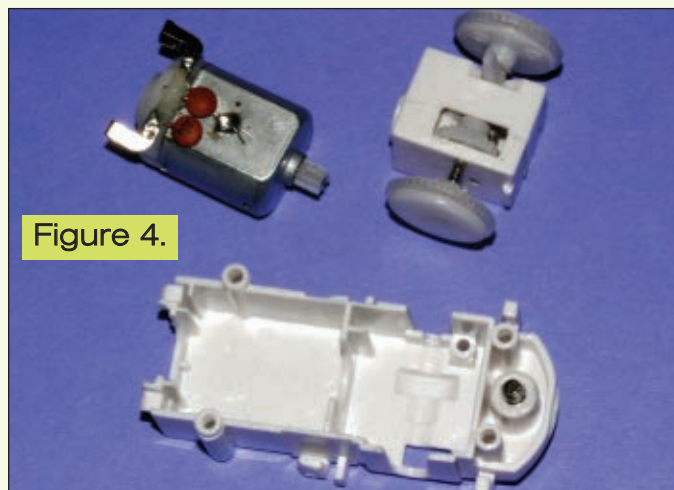


Figure 4.

Figure 3 shows the drive module removed from the shell. In this figure, the fur-covered shell is upside down and the nose of the robot is pointing down and left. The rectangular drive module is shown upright, also aligned to the lower left corner of the figure. The components of the drive module – a DC motor and gear box – are shown in **Figure 4**. The only electrical connection to the drive module is the pair of contacts soldered directly to the DC motor. Each terminal is bypassed to the casing of the motor with a ceramic disc capacitor.

The control logic and sensors are contained in a second module connected to the fur-covered shell. **Figure 5** shows the module separated from the shell. You can see the two momentary contact buttons on the top side of the circuit board on the right, and the eight ohm, 1/4W speaker in the rear of the robot shell. The white and tan plastic discs on the shell interface with the two momentary switches on the top of the circuit board. **Figure 6** shows details of the nose button assembly. The masking tape is used to hold the twisted wires together and to provide insulation. I would have preferred a soldered connection, but I suppose masking tape is adequate for the low-power audio signal.



Figure 5.

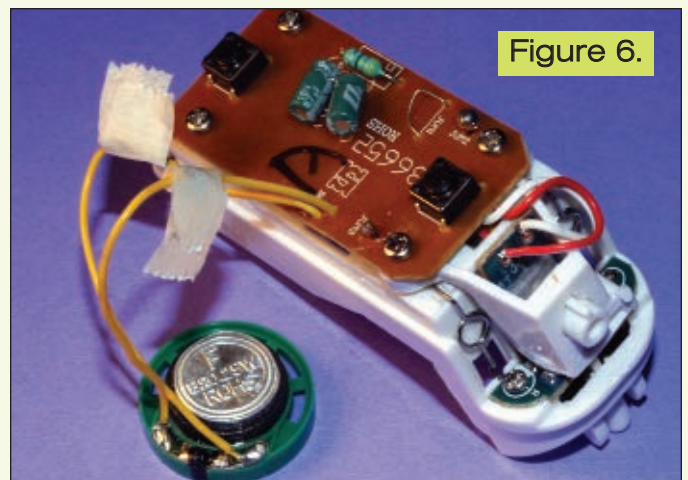


Figure 6.

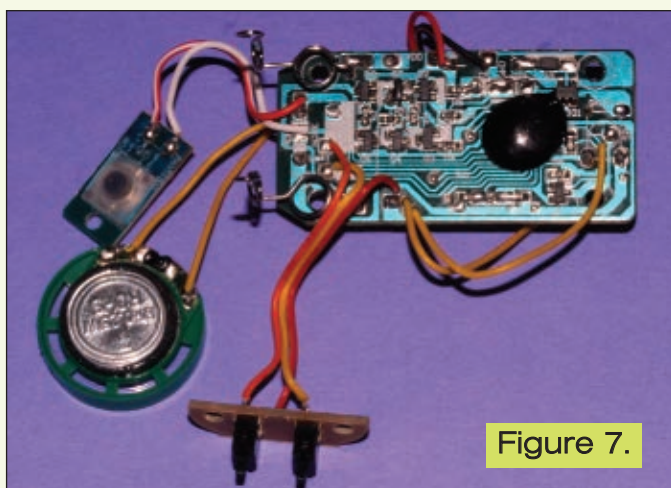


Figure 7.

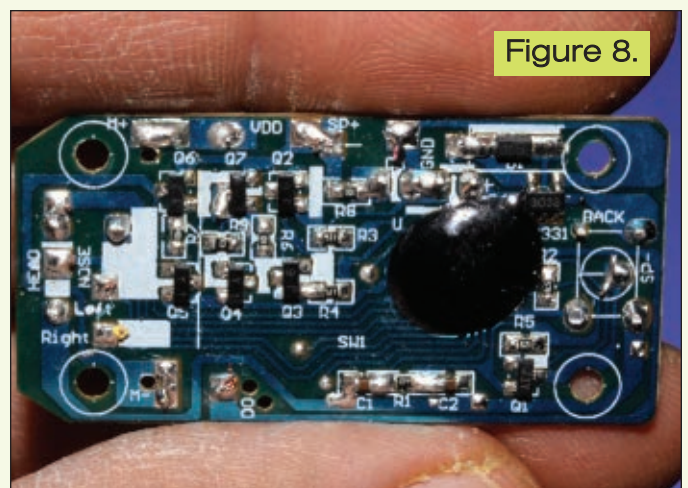


Figure 8.

Figure 7 shows the underside of the control circuit board and a view of the two data readers (bottom, left) and the elastomeric nose button (middle, left). A close-up of the control circuit board with the wires removed is shown in **Figure 8**. The board is populated with SMT components: seven transistors, a voltage regulator, a diode, seven resistors, and two capacitors. The top side of the board holds two leaded electrolytic capacitors and a leaded 1/8W resistor. The heart of the board – the microcontroller – is hidden under the blob of black epoxy.

In case you simply must see what's under the blob, there are two approaches that I've used with good success. The first is to heat the epoxy with a hot air gun and then gently tear at the epoxy with tweezers. When hot, the epoxy has a consistency of putty. The other approach is to use an epoxy solvent – which produces great results. The problem with an epoxy solvent is toxicity – so much so that I advise against it unless you have access to a hooded laboratory work environment and know how to use it. The microcontroller provides the digital to analog conversion for the goofy words and constant chattering of the robot, as well as the switching logic. Touch the back button and the robot activates and

moves about for four minutes before returning to sleep or standby mode. Touch the back button when the robot is active and it goes to sleep. The head button also has dual functionality: it's a backup button when the robot is on the move and a talk button when in sleep mode.

On my to-do list is installing the circuit board on my Traxx R/C truck, hopefully resulting in a semi-autonomous, cat-size robot pet. I plan to install a MOSFET switch between the truck's NiMH battery pack and the motors, and drive the MOSFET with the output of the circuit board. I'll also extend the nose switch to several switches on the bumper of the Traxx truck. The larger issue is how to best cover the robot so that it doesn't damage itself or the environment. Perhaps a skunk or cat hand puppet will do the trick.

If you manage to successfully repurpose the Zhu Zhu brain, please share your story. **NV**

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MAGNETIC MEASUREMENT DRAWS ATTENTION

On page 12 of the March '10 issue, the Earth's magnetic field is said to be "only somewhere between 30 and 60 T, depending on how close to the poles you measure it." That was a rather surprising pronouncement to me and doesn't make much sense with the rest of the article either since it would imply that this great new "super" magnet is weaker than the Earth's own magnetic field. It would appear that someone slipped a few decimal places as those units should have been micro-Teslas.

Roland B. Roberts, PhD
Brooklyn, NY

Yes, indeed! My original document said μT (microtesla). Apparently, when going from a word processor to html (which is how I submit the articles), the mu disappeared. Thanks for pointing that out.

Jeff Eckert

PREFERS PAPER

Great magazine. I've enjoyed reading many articles over the years. I have so many projects, I don't seem to be able to finish them all. Things advance at much too fast a pace and it's hard to keep up, but it is nice to be able to pick up a hard copy rather than browsing the mag via computer screen. Very much enjoy the paper copy.

William Runyon

GETTING THE DOWNLOAD

Can someone tell me where to download PropBASIC from the March '10 Spin Zone column, and how to get it running?

Kevin Hines

As PropBASIC is a user product and not yet officially sanctioned by Parallax, it can be found in this thread in the Propeller forum.

<http://forums.parallax.com/forums/default.aspx?f=25&m=412552>

After I submitted that article, PropBASIC has been incorporated into the BST IDE — it has the same look and feel as the Propeller Tool but is cross-platform. So Windows, Mac, and Linux users can program the Propeller chip. This is the reason I created the Propeller Platform for my column — it's a better "Arduino" than the Arduino (the Propeller is vastly more powerful), and with BST one can use any of the major operating systems to do their programming (just like with the Arduino).

Jon Williams

COOL APPS FOR STINGRAY

I've been studying the Dec '09 column on the Stingray robot kit. The sidebar on the book about programming the Propeller chip and Vern Graner's mention of intelligent HVAC green house design got my attention.

Does his chapter in the book make use of the MSR1 board that comes with the Stingray? I see the board can be ordered separately.

I can easily imagine a Stingray going from room to room in a house, sending temperature control instructions to the HVAC system depending on whether it senses people are in the room. Another application for the Stingray that seems interesting is people monitoring. My mother has brain cancer and is at the point where she cannot walk unassisted (she uses the combination of a walker and a wheelchair) and she has a problem with falling.

It is not possible for us to monitor her 24x7x365 but perhaps a Stingray can be customized to send SOS telephone calls and text messages if my mother falls while trying to move from here and there. For example: Mom crashes to the floor. The Stingray hears this or feels it or hears a distress cry from her. It travels to her and asks her "Do you need help?" If she answers "Yes" then the Stingray sends a text message to both my sister and me, and then places a voice call to my sister and my wife.

The challenge here would be adding appropriate sensors, speech, and cell phone circuitry to the Stingray. The Stingray would have to survive a dog and three cats, and every now and then a gecko. Maybe I'll order the Stingray and try to customize it.

Bob Cochran

Hi Bob! Thank you for taking the time to write. Actually, the book was written before the MSR1 was released ... quite a ways before, really. I used the Propeller proto board for the project by creating a daughter board. Even if the board had been available back then, I don't think it would have made a good match for this project. I feel the MSR1 is better suited to robotics use rather than to get stuffed behind a wall plate and used as a thermostat.

I like your concept on temperature monitoring. Of course, I'd have to provide navigation, two-way communication, and some way to "park" the bot on a charging station which is fairly tricky.

Seems like it might be an interesting idea for a "sentry bot" of sorts. Have it monitor temperature and other environmental elements as it roves the grounds like a security guard. Maybe have it park and use a motion sensor to see if anything is moving around it.

Continued on page 77

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

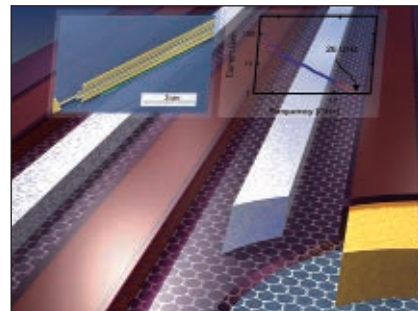
IBM DEVELOPS FASTEST GRAPHENE TRANSISTOR

You probably haven't heard of it, but the Defense Advanced Research Projects Agency (DARPA; www.darpa.mil) funds a program called Carbon Electronics for RF Applications (CERA) which is basically aimed at developing "techniques to synthesize high-quality graphene films on a wafer scale, to engineer a graphene bandgap, to build high-performance RF transistors, and to integrate the transistors for a low-power, high-performance, low-noise amplifier." The latest development comes from IBM's T. J. Watson Research Center (www.watson.ibm.com) in the form of a graphene transistor with the highest cut-off frequency achieved so far for any such device: 100 GHz. Notably, this is already better performance than you can get with silicon transistors with

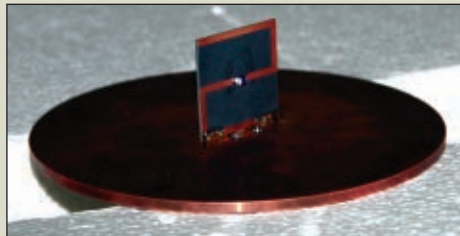
■ IBM's graphene field-effect transistor has achieved a record cutoff frequency of 100 GHz.

the same 240 nm gate length (about 40 GHz).

The device is based on a single atom-thick layer of carbon atoms bonded in a hexagonal chicken-wire-like arrangement that offers some unique electrical, optical, mechanical, and thermal properties. These properties are still being explored to determine the material's range of technological applications. The bottom line is, however, that this breakthrough demonstrates that graphene may be a major player in the next generation of high-performance devices and ICs. ▲



BREAKTHROUGH ENABLES TINY ANTENNAS



■ This NIST-tested antenna employs a Z element metamaterial inside a 30 mm square that boosts its signal.

The National Institute of Standards and Technology (NIST; www.nist.gov) recently announced the successful test of some novel antennas, developed in conjunction with the University of Arizona and Boeing Research & Technology, that break the rules relating to size vs. signal. According to NIST, "The new antennas radiate as much as 95 percent of an input radio signal and yet defy normal design parameters. Standard antennas need to be at least half the size of the signal wavelength to operate efficiently. At 300 MHz, for instance, an antenna would need to be half a meter long. The experimental antennas are as small as one-fiftieth of a wavelength and could shrink further."

The antennas employ a metamaterial that makes them behave like much larger ones by storing and reradiating the energy. Interestingly, "these metamaterials are much more 'frequency agile,'" according to NIST engineer Christopher Holloway. "It's possible we could tune them to work at any frequency we want, on the fly." The new antennas are expected to be particularly useful in constantly shrinking wireless systems such as communications devices, microsensors, and ground-penetrating radars. ▲



ERSATZ FLYTRAP EATS CESIUM

It's not a panacea for the problem of nuclear waste, but some researchers at Northwestern University (www.northwestern.edu) have published a paper describing a synthetic material — based on layers of gallium, sulfur, and antimony — that they say snaps up radioactive cesium from a sodium-heavy solution like a venus flytrap gobbles up insects. The cesium itself triggers a change in the material, causing it to close its pores and trap the cesium ions inside. Sodium

■ A synthetic version of this flytrap extracts cesium from radioactive waste.

does not affect the material, so it is highly selective in removing the otherwise difficult-to-isolate cesium. It's not exactly capable of turning waste into Perrier, but

COMPUTERS AND NETWORKING

NEW DESKTOP USES AMD CHIPS

Most of the attention these days goes to machines on the laptop scale or smaller, but Lenovo (www.lenovo.com) has introduced the ThinkCentre A63 desktop featuring your choice of AMD Sempron™, Athlon™ II, and AMD Phenom™ II processors. Aimed at small to medium businesses, they start at a miserly \$329. A typical setup with a 2.7 GHz Sempron, 2 GB of SDRAM, and a 320 GB drive will run you \$479, which is still not a budget breaker. Included in the package is the company's "Enhanced Experience for Windows 7," designed to save time during bootup and shutdown; Direct X10 integrated graphics support high-end 3-D applications needed for activities like engineering, graphic design, and film production. You can add a high-res webcam and preloaded Skype for VoIP activities, and a range of security tools are available. ▲

■ Lenovo's AMD-powered ThinkCentre A63 desktop.



YOUR OWN CUSTOM FONT ... ALMOST FREE

Assuming that your handwriting is actually legible, you might be interested in a service provided by High-Logic B.V., publisher of the FontCreator font editor. All you have to do is go to www.yourfonts.com and follow the seven-step process, and you'll end up with an OpenType font created from your own handwriting that is usable on Windows, Mac, and Linux systems. The font can have more than 200 characters and include your complete signature for use in correspondence and legal documents. The service costs \$9.95, but you are not obligated to pay unless you are satisfied. And some people are just never satisfied. ▲

ERSATZ FLYTRAP EATS CESIUM CONTINUED

according to the paper's senior author, "A new class of materials that takes advantage of the flytrap mechanism could lead to a much-needed in nuclear waste remediation." This is significant, as cesium-137 — a leftover from power plants and weapons — is a dangerous carcinogen that can trigger disease even decades after exposure.

Interestingly, the flytrap effect was unexpected, and the researchers were actually studying various structures of the material to determine if they could be used as ion exchangers. They did not expect a dynamic response mechanism. The entire paper, called "Selective Incarceration of Caesium Ions by Venus Flytrap Action of a Flexible Framework Sulfide," is available online at Nature Chemistry (www.nature.com), but it will cost you \$32. ▲

TURN YOUR HDTV INTO A VIDEOPHONE



■ Demonstration of "Viera Cast" which provides Skype services on Panasonic HDTVs.

Speaking of Skype (www.skype.com), look for the service to come packaged with Panasonic and LG video products starting this spring. At the last Consumer Electronics Show, Panasonic announced a collaboration that adds Skype software to its Viera sets, allowing voice and video communications via HDTV. This builds on Skype's existing PC and mobile phone platforms so you will soon be able to experience the same spotty quality and unreliable connections in your own living room.

The hardware implementation (rumored to cost about \$100) includes four microphones embedded in the webcam unit which use beam-forming technology to detect and focus on whoever is speaking. The "Viera Cast" service includes a range of familiar Skype features such as free voice and video connections, cheap calls to both land and cell phones, voicemail, and conference calls with as many as 24 other parties. Skype has a similar deal with LG, which will provide the service on 26 of its LED, LCD, and plasma sets.

Regardless of the hardware setup, you will be prompted to accept or reject an incoming call before it blows away whatever you're watching and reveals your repulsive semi-clothed body to the caller. There's no telling what you'll see coming in from your crazy friends on the other end, though, so blindfold the kids. ▲

CIRCUITS AND DEVICES

CHIPS PROVIDE LOW-COST DRIVER ASSISTANCE



■ The Renesas SH74552 driver assistance MCU, designed for less expensive cars.

If you drive a high-end luxury car, there's a good chance that it's equipped with an advanced driver assistance system. These are designed to detect likely accident conditions such as driver inattentiveness, poor visibility, the head-on approach of a cement truck, and so on. In operation, data is collected by millimeter-wave radar, cameras, and other sensors, and relayed via a controller

area network (CAN) to a sensor fusion electronic control unit (ECU) that uses it to perform control functions. High-end systems are costly, though, so car manufacturers have been offering them only on their most expensive models. A couple months ago, however, Renesas Technology America (www.renesas.com) introduced a pair of MCUs in which the specifications "have been carefully selected for systems intended for popularly priced vehicles." In other words, to be cheap enough for econo-boxes and "eco-friendly" cars.

The SH74552 and SH74562 MCUs feature a compact 13 x 13 mm package, 160 MHz operation (as compared to 240 MHz in more expensive devices), 1 MB of high-speed on-chip Flash memory, and on-chip functions such as four-channel CAN. In addition, the SH74552 is equipped with a two-channel FlexRay (a communication protocol promoted by the FlexRay Consortium, www.flexray.com) controller. The specs are extensive and complicated, but the bottom line is that the devices — which come in 176-pin BGA format — will be priced at \$89 and \$100 each, making them feasible for more affordable vehicles. Sample shipments will begin in May in Japan only. No date was provided for availability elsewhere. ▲

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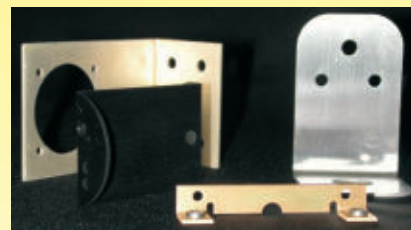
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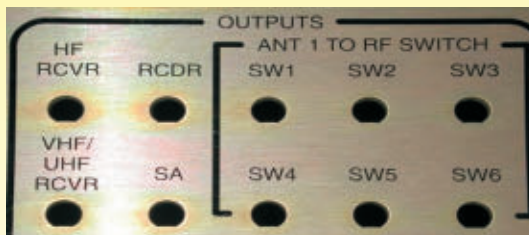
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MICROCONTROLLERS AIM FOR SMART METERS

If you have ever wondered why the power company can cut off your power from 100 miles away but still needs to send some poor schlepper into your yard every month to see how much juice you've used, it's because most of the 2.5 billion electric meters are still electromechanical devices much like the one invented by Elihu Thomson in 1888. There is some movement finally toward replacing them with "smart" meters as part of a smart grid system, however.

NEC Electronics (www.am.necel.com) intends to ride the wave with new eight-bit LCD microcontrollers that contain an "integrated metrology engine" that provides both automatic meter reading and energy management. The 64-pin 78K0/LE3-M MCU comes in a 10 x 10 mm low-profile quad flat package (LQFP) and is designed for single-phase two-wire meters. The 100-pin 78K0/LG3-M comes in a 14 x 14 mm LQFP and is designed for single-phase three-wire meters.

The metrology engine consists of a high-precision 24-bit delta-sigma A/D converter; power calculation hardware with calibration capability; management circuits to detect power outages, current peaks, and voltage peaks; and anti-tampering circuits. Also included is an LCD controller that can drive up to a 160 segment display plus up to 50 kB of

Flash memory. Pricing starts at \$3.45 in 10,000-unit lots, so the power company should be able to write off the cost the first time it eliminates a visit. Mass production starts about the time you read this, but it may take a while to get to the 2.5 billion level. ▲

INDUSTRY AND THE PROFESSION

SAMSUNG AND RAMBUS KISS AND MAKE UP

In 2004, Rambus, Inc., filed a patent infringement suit against Samsung — among others — and it was scheduled to go to trial last January. But at the relative last minute, they came to what seems like a positively kissy-face agreement. Under the terms, Samsung will pay Rambus an initial \$200 million, sweetened by an additional \$25 million per quarter for five years. Samsung will also invest \$200 million in Rambus and participate in a joint effort to design a new generation of memory technologies. In return, Samsung gets to admit no wrongdoing and avoids participation in similar suits against Hynix Semiconductor and Micron Technology. Now, aren't you sorry you dropped out of engineering school? **NV**

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PICAXE PRIMER

SHARPENING YOUR TOOLS OF CREATIVITY

■ BY RON HACKETT

PROGRAMMING THE MAX7219 LED DISPLAY DRIVER

In the previous installment of the PICAXE Primer, we developed a serially interfaced four-digit peripheral LED display that can be used in any PICAXE project — even one powered by the little 08M. This month, we'll experiment with three different programs for our display and one for our 28X1 master processor. First, we'll try out a simple program to count from 0 to 9999, and then we'll throw in a little "zero-blanking" for good measure. When our LED display has learned how to count, we'll install driver software on it that will enable our master processor to send serial data to the LEDs using only one output pin.

In the last few months, I have received three or four emails requesting that I devote more attention to the process of software development in the Primer. So, rather than just providing the completed software programs that we will be using this month, we're going to spend a little more time focusing on the actual process of software development. If you find this to be a helpful approach, let me know via email at Ron@JRHackett.net. If you don't, please let me know that as well.

LEARNING TO COUNT

The counting aspect of our first program is a relatively simple process; all we need to do is define a variable, and then repetitively increment it in a simple loop. Historically, the more difficult aspect of this process has been isolating each digit in the count for transmission to a terminal or display. For example, suppose the current count is 5286. How do you separate each of the digits for a

serial transmission? The answer involves a fairly complicated sequence of modular arithmetic. If you're up for a challenge, you might want to give it a try.

On the other hand, if you want the easy answer, it's the PICAXE *bintoascii* command. The complete syntax for the *bintoascii* command has two different forms: one for a byte variable and one for a word variable. Since we want to count from 0 to 9999, we need the form that uses a word variable. The complete syntax of this version is *bintoascii wordvariable, tenthousands, thousands, hundreds, tens, units*. The last five arguments of the command refer to the standard "positional" notation for a decimal number.

For example, the number 62879 has a 6 in the *tenthousands* position, a 2 in the *thousands* position, an 8 in the *hundreds* position, a 7 in the *tens* position, and a 9 in the *units* position. Since a word variable can be as large as 65535, the *bintoascii* syntax for word variables always requires a *tenthousands* digit. Therefore, a count of 5286 has a 0 in the *ten thousands* position, even though it's rarely displayed.

In order to use the *bintoascii* command to write a program that can count from 0 to 9999, we will need to include some variation of the variable definitions shown below. (We have already discussed the first three definitions in the previous Primer column.)

```
' === Variables ===
symbol outword = w0 ' concatenation of maxreg & outbyte
symbol outbyte = b0 ' data to be sent to the 7219
symbol maxreg = b1 ' 7219 register that receives data
symbol tths = b3 ' digit in the "tenthousands" position
symbol thos = b4 ' digit in the "thousands" position
symbol hnds = b5 ' digit in the "hundreds" position
symbol tens = b6 ' digit in the "tens" position
symbol ones = b7 ' digit in the "ones" ("units") position
symbol counter = w4 ' word variable to count from 0 to 9999
```

The beauty of the *bintoascii* command is that it automatically converts each of these digits to the corresponding ASCII code, which is exactly what we need for a serial transmission. However, we're not there yet; we just want the LED display board to count from 0 to 9999, with no serial transmission involved. In order to get it to do that, we need to convert each digit back from ASCII to the digit itself. Fortunately, that's an easy task. The ASCII code for "0" is 48, the code for "1" is 49, the code for "2" is 50, etc. In other words, the ASCII code is always greater than the digit itself by exactly 48. All we need to do is to subtract 48 from each *bintoascii* argument to get back to the value of the digit itself:

```
bintoascii counter,
tths,thos,hnds,tens,ones
thos = thos - 48
hnds = hnds - 48
tens = tens - 48
ones = ones - 48
```

Note that we don't need to convert the *tths* variable back from ASCII because we aren't going to need it on a four-digit display. Once we have converted the four digits that we will be using, we just send each one of them to the corresponding LED on our display:

```
maxreg = 1    'first LED from
outbyte = thos'left (thousands)
gosub shout
```

```
maxreg = 2    'second LED from
outbyte = hnds'left (hundreds)
gosub shout
```

```
maxreg = 3    'third LED from
outbyte = tens'left (tens)
gosub shout
```

```
maxreg = 4    'fourth LED from
outbyte = ones'left (ones)
gosub shout
```

The above code snippets are all we need to add to our *LED7219help.bas* program (we used this in the previous Primer to test the LED display) to convert it into a counting program. The resulting program (*LED7219Count.bas*) is available on the N&V website at

www.nutsvolts.com. Download it, along with the three other programs that we will be using this month: *LED7219CountZB.bas*, *LED7219Driver.bas*, and *LED7219Test.bas*, and try it out. To program the on-board 08M, you will need the same four-pin programming adapter that you used last time. When you install and run *LED7219Count.bas* on the LED display, you should see it count from 0 to 9999; of course, you will also see all the "leading zeros" displayed as well (e.g., "27" is displayed, as "0027"). Since this is not the optimum format for displaying a number on LEDs, let's see what we can do to improve the program.

ZERO-BLANKING

In order to get the superfluous zeros to not appear on the display, we'll need to do some *if-then* type testing to determine whether or not to "blank" a zero. Let's start with the simplest digits and work our way up to the harder ones. The ones digit doesn't require any testing at all; a zero in that position should **never** be blanked. The thousands digit is almost as simple because a zero in that position should **always** be blanked on a four-digit display. The remaining two positions (hundreds and ones) are more complicated because sometimes we want to blank a 0 in either (or both) of these positions, and sometimes we want to display it.

Again from last time, you may recall that the BCD decoding schema of the 7219 includes a value of 15 to display a blank on any of the LEDs. Therefore, our little "zero-blanking" project requires that for each of the digit positions except the ones digit, we include the necessary if-then test on the relevant variable. If its value is 0 and it should be blanked, we need to change its value from 0 to 15 so that the digit will be displayed as a blank, not a 0. Before you read any further, you may want to experiment with the *LED7219Count.bas* program to see if you can add the necessary *if-then* statements to correctly zero-

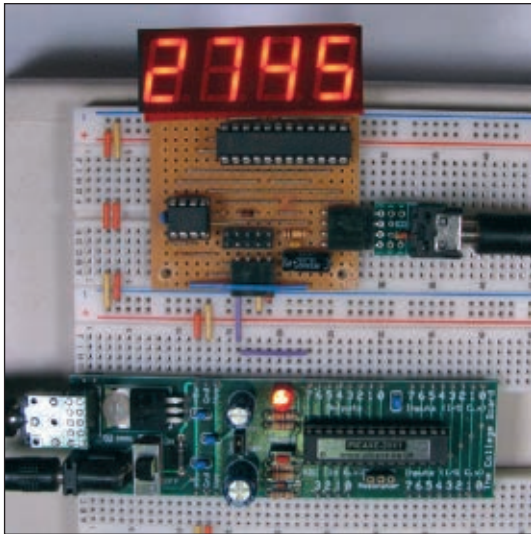
blank the LED display. (Actually, you can read further if you want — the answer isn't in the Primer anyway; it's in the *LED7219CountZB.bas* program on the N&V website.) See if you can develop the necessary code to successfully zero-blank the LED display. If not, take a look at the *LED7219CountZB.bas* program; it contains one possible solution to the problem.

CONFIGURING THE LED DISPLAY AS A STAND-ALONE SERIAL PERIPHERAL

When you're sure you understand the programming involved in zero-blanking, we're ready to move on to our goal of configuring the LED display as a stand-alone serial peripheral that we can use with any PICAXE project. The necessary driver software is actually very similar in structure to the driver program we used for our LCD display a few months ago. In the main program loop, we need to wait for the master processor to serially send a four-byte data string. Once the string is received, it's a simple matter to display each byte on the appropriate LED. The driver doesn't need to worry about zero-blanking or anything else; in effect, our little LED display is just a dumb output terminal. The master processor is responsible for zero-blanking when it's needed. All the LED driver does is dutifully display the four characters it receives.

Note that I said "characters." There's no reason the master processor can't send "HELP" or "HOHO" or whatever. If you want even more flexibility, you could turn off the 7219's BCD decoding and set up a lookup table to display even more characters. (I'll leave that one for you as a little programming challenge!)

If you do decide to modify the driver software (or the 28X1 test program we are about to discuss), be sure to remember that there are essentially four things upon which

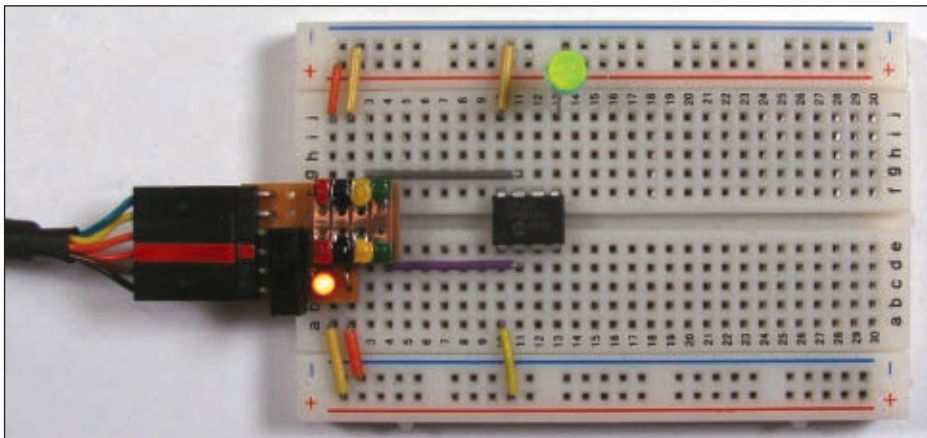


■ FIGURE 1. LED Display with Master Processor.

the master processor program and the LED driver software must agree:

1. Both processors must use the same baud rate. I chose 4800 baud because that's the highest baud rate that all PICAXE processors can implement.
2. Each serial transmission must contain exactly four characters. The 08M on the LED display will "hang" if that's not the case.
3. The four characters will be displayed from left to right on the LEDs.
4. As long as BCD decoding is enabled, there are only 16 different characters that are allowed: 10 digits, a dash, a "blank," "H," "E," "L," and "P."

■ FIGURE 2. AxMate Programming Connection.



TESTING THE SERIALIZED LED DISPLAY

In order to test our new peripheral device, we'll need to connect it to the master processor board. **Figure 1** shows the setup that I used. In the photo, I have inserted the LED board into the breadboard via the LED's 5X2 ribbon cable connector.

I did it that way so that the LED display would lay flat on the breadboard (which makes it easier to

photograph). It also gave me the opportunity to construct yet another programming adapter that you can also see in the photo.

All I did was use a right-angle male header rather than a straight male header for the four-pin programming connection that we need. That way, the adapter is able to mate with the programming connector with everything laying flat against the breadboard.

Of course, you probably won't be photographing your setup, so you don't need a different adapter — the one you used last time will work fine. I connected the 28X1's PortB pin 7 output to the RxD input of the LED board (the left-most pin on the four-pin breadboard connector). Of course, you can change that arrangement, but you would also have to modify the test program that I used.

When you download the

LED7219Driver.bas software and take a look at it, you'll see how simple it is. You will also see that I have changed the names of the five main variables from *tths*, *thos*, *hnds*, *tens*, and *ones* to *char0*, *char1*, *char2*, *char3*, and *char4*. I did this to emphasize the fact that we're sending and receiving characters, not just digits.

One other aspect of the program requires an explanation. I wanted to be sure that on power-up, the LED display would be blank. The following code snippet accomplishes that task:

```
maxreg = 1
outbyte = blank
gosub shout
```

```
maxreg = 2
outbyte = blank
gosub shout
```

```
maxreg = 3
outbyte = blank
gosub shout
```

```
maxreg = 4
outbyte = blank
gosub shout
```

As soon as you see that code snippet, I know what you'll be thinking: "Ron's really losing it — why doesn't he just use a simple *for-next* loop and save the space?" I actually did exactly that. My first version was:

```
for maxreg = 1 to 4
  outbyte = blank
  gosub shout
next maxreg
```

Guess what — it didn't work (at least for me)! This is a complete mystery to me. Either I'm overlooking something really obvious, or there's something weird about how the *for-next* loop updates *maxreg* each time through the loop. Try it and see if it works for you. If you have any clue to help me solve the mystery, let me know!

When you have your master processor properly connected to the LED display, use the Programming Editor to download the *LED7219Driver.bas* software to the display and *LED7219Test.bas* to your 28X1 master processor.

You should again see the 0 to

9999 count appearing on the LED display. This time, however, the count is being produced by the 28X1, not the 08M. Also, you'll see that I didn't include the zero-blanking code in the 28X1's test program — I left that little chore for you!

WHAT'S NEXT?

So, that's it for our LED display. We have successfully constructed another stand-alone serial peripheral for use with our PICAXE projects. I'm sure you have a couple of pet projects that could make good use of a four-digit LED display — I know I do.

The first thing that comes to mind is a countdown timer. The 28X1's *settimer* command would make a timer project relatively easy to implement. We may do exactly that in one of the future installments of the Primer. In the meantime, you may want to give it a try on your own.


In any case, I have an entirely different sort of project in mind for our next Primer. I have been working on a new way to power and program PICAXE projects. (How's that for alliteration?) This approach — which I call the AxMate — is capable of implementing both these functions (power supply and programming adapter) in a circuit that occupies less than 1/2 square inch of space.

To whet your appetite, **Figure 2** shows the stripboard circuit that we will be constructing. This little AxMate board is powering the 08M circuit that's installed on the breadboard, and I also used it to download a simple "Hello World!" program to the 08M.

As you can see, there is no other power connection to the breadboard; the AxMate board provides the power connections, as well as the necessary programming connections. One tiny board and one cable is all it takes.

I'm really pleased with the AxMate project, and I hope you will enjoy it as well.

See you next time. **NV**



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- ✓ Front panel digital control and display of all settings and parameters!
- ✓ Professional metal case for noise-free operation
- ✓ EMI filtering on audio and power inputs
- ✓ Super audio quality, rivals commercial broadcasts
- ✓ Available in domestic kit or factory assembled export versions

For nearly a decade we've been the leader in hobbyist FM radio transmitters. We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!



The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version with 1W output for our export only market!

All settings can be changed without taking the cover off! Enter the setup mode from the front panel and step through the menu to make all of your adjustments. A two line LCD display shows you all the settings! In addition to the LCD display, a front panel LED indicates PLL lock so you know you are transmitting.

Besides frequency selection, front panel control and display gives you 256 steps of audio volume (left and right combined) as well as RF output power. A separate balance setting compensates for left/right differences in audio level. In addition to settings, the LCD display shows you "Quality of Signal" to help you set your levels for optimum sound quality. And of course, all settings are stored in non-volatile memory for future use!

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish black metal case measures 5.55"W x 6.45"D x 1.5"H. (Note: After assembly of this do-it-yourself hobby kit, the user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for end delivery outside the continental US.)

FM30B Digital FM Stereo Transmitter Kit, 0-25mW, Black

\$199.95

FM35BWT Digital FM Stereo Transmitter, Assembled, 0-1W, Black (Export ONLY)

\$299.95

Pocket Audio Generator

A perfect test source for stereo line inputs on any amplifier or mixer. Provides 50Hz, 100Hz, 1kHz, 10kHz, & 20kHz tones, plus 32 bit digital pink noise. Great to help you identify cables or left/right reversals! Stereo RCA line level outputs. Uses 2xCR2025, not included.



K8065 Pocket Audio Generator Kit

\$32.95

Pocket Vu Meter

Hand held audio level meter that fits in your pocket! Built-in mic picks up music and audio and displays it on an LED bargraph. Includes enclosure shown. Runs on one 3V Li-Ion button cell, not included. If you ever wanted an easy way to measure audio levels, this is it!



MK146 Pocket Vu Meter Kit

\$8.95

Mini LED Light Chaser

This little kit flashes six high intensity LEDs sequentially in order. Just like the K80302 to the right does with incandescent lights. Makes a great mini attention getter for signs, model trains, and even RC cars. Runs on a standard 9V battery.



MK173 Mini LED Light Chaser Kit

\$15.95

Running Light Controller

Controls and powers 4 incandescent lights so they appear to "travel" back and forth (Like the hood on KITT!). Great for the dance floor or promotional material attention getters, exhibits, or shows. Runs on 112-240VAC.



K8032 4-Channel Running Light Kit

\$38.95

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.



MK171 Voice Changer Kit

\$14.95

Steam Engine & Whistle

Simulates the sound of a vintage steam engine locomotive and whistle! Also provides variable "engine speed" as well as volume, and at the touch of a button the steam whistle blows! Includes speaker. Runs on a standard 9V battery.



MK134 Steam Engine & Whistle Kit

\$11.95

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

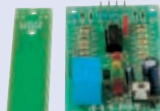


LTS1 Laser Trip Sensor Alarm Kit

\$29.95

Liquid Level Controller

Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.



K2639 Liquid Level Controller Kit

\$23.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!



MC1 Mini Electret Condenser Mic Kit

\$3.95

Sniff-It RF Detector Probe

Measure RF with your standard DMM or VOM! This extremely sensitive RF detector probe connects to any voltmeter and allows you to measure RF from 100kHz to over 1GHz! So sensitive it can be used as a RF field strength meter!



RF1 Sniff-It RF Detector Probe Kit

\$27.95

The High Tech Spotlight!

50W FM Station-In-A-Box

- ✓ 50w RF output!
- ✓ Dual program source decks!
- ✓ Laptop input!
- ✓ USB input!
- ✓ Dual mics, antenna, and all accessories!
- ✓ Just plug it in and you're on-the-air!



YES, a complete FM stereo radio station in-a-box! We pioneered the concept over a decade ago, and now thousands of them are deployed around the world!

The concept? It's simple. Whether your application is for disaster preparedness, military, educational, LPFM, or standard FM backup, wherever you may need to get on-the-air quick, without any hassles, the Ramsey PXB series is your immediate solution... Setup the antenna, plug it in, and you're on-the-air!

This 50W version is based on our proven and ultra reliable FCC Certified PX50 FM stereo transmitter designed for simple operation via the front panel navigation switch matrix. All controls and status messages are displayed on the 2 line by 20 character vacuum fluorescent display. Automatic protection circuits are designed to keep you on the air, rather than off. To compliment the transmitter we include our 3.4dB gain omnidirectional FM broadcast antenna and 100' of low loss LMR400 feed line with pre-assembled & tested connectors.

From there we give you 2 separate CD-MP3-SD-USB media players as well as an external (laptop, etc) input, all prewired into a professional 5 channel stereo mixer. 2 dynamic handheld microphones, XLR cables, clips, and desk stands are included for local origination. We top it all off with two sets of professional stereo monitor headphones.

The entire unit is factory assembled in a small 6 rack unit mil-spec shock case, and burned in at full power for 12 hours. Over 15 different models are available, with power ratings from 50 watts to 1,000 watts. Visit www.ramseyfm.com for details.

PXB5006D935 FM Radio Station \$5195.00

High Power LED Driver

High power LED's have finally found their way into the hobbyist budget, but now you need a driver! This little board provides the accurate and constant current needed to drive them. Delivers 350mA or 700mA at a constant current



K8071 High Power LED Driver Kit

\$14.95

Digital Voice Changer

This voice changer kit is a riot! Just like the expensive units you hear the DJ's use, it changes your voice with a multitude of effects! You can sound just like a robot, you can even ad vibrato to your voice! 1.5W speaker output plus a line level output! Runs on a standard 9V battery.



MK171 Voice Changer Kit

\$14.95

Electronic Watch Dog

A barking dog on a PC board! And you don't have to feed it! Generates 2 different selectable barking dog sounds. Plus a built-in mic senses noise and can be set to bark when it hears it! Adjustable sensitivity! Unlike the Saint, eats 2-8VAC or 9-12VDC, it's not fussy!



K2655 Electronic Watch Dog Kit

\$39.95

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

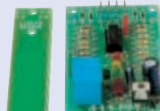


LTS1 Laser Trip Sensor Alarm Kit

\$29.95

Liquid Level Controller

Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.



K2639 Liquid Level Controller Kit

\$23.95

Stereo Ear Super Amplifier

Ultra high gain amp boosts audio 50 times and it does it in stereo with its dual directional stereo microphones! Just plug in your standard earphone or headset and point towards the source. Incredible gain and perfect stereo separation!



MK136 Stereo Ear Amp Kit

\$9.95

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!



MC1 Mini Electret Condenser Mic Kit

\$3.95

Broadband RF Preamp

Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

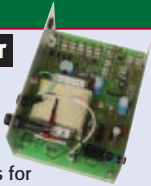


PR2 Broadband RF Preamp

\$69.95

Vintage Battery Eliminator

Collectors come across some great deals on antique battery-powered radios, but how to power them is a real problem. Many classic radios operated on batteries only, and in many cases a series of three batteries for each radio were required!



The new ABCE1 Battery Eliminator gives you an easy way to replace all these batteries with a simple household AC power connection and resurrect your vintage antique radios! Provides "A" filament, "B" plate, and "C" control grid supplies, which are all isolated from each other. Complete with aluminum case. Runs on 110-240VAC.

ABCE1 Vintage Radio Battery Elim Kit \$199.95

Digital Message System

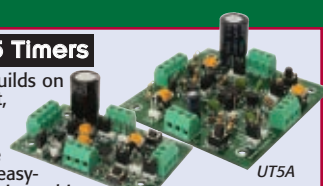
The third generation of Ramsey digital voice storage kits! We started with the latest digital voice storage technology. It provides up to 8 minutes of digital storage at a frequency response up to 3.5 KHz. (Total message time and frequency response is dependant on selected internal sampling rate.) Once recorded, messages are available for playback on-demand or automatic continuous looping. Standard RCA unbalanced line level output is provided for easy connection to any amplifier, amplified speaker, mixer, or sound system. In addition, a standard 4-8 ohm speaker output is provided to directly drive a monitor speaker. Can be remote controlled via 3-wire BCD with our interface options. Check www.ramseykits.com for all options!



DVMS8 Digital Voice Storage 8Ch Kit \$99.95
DVMS8WT Assembled DVMS8 \$149.95

Ultimate 555 Timers

This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.



All connections are easily made through terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

UT5A Through Hole 555 Timer/Osc Kit \$24.95
UT5AS SMT 555 Timer/Osc Kit \$26.95

Passive Aircraft Monitor

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.



ABM1 Passive Aircraft Receiver Kit \$89.95

Voice Activated Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch or to turn on a recorder or light! Directly switches relays or low voltage loads up to 100mA. Runs on 6-12 VDC.



VS1 Voice Switch Kit \$9.95

OBDII CarChip Pro

The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!



8226 CarChip Pro OBDII Monitor-Asmb \$99.95

RF Preamp

The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.



SA7 RF Preamp Kit \$19.95

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.



TS1 Touch Switch Kit \$9.95

Doppler Direction Finder

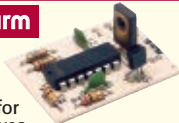
Track down jammers and hidden transmitters with ease! 22.5 degree bearing indicator with adjustable damping, phase inversion, scan and more. Includes 5 piece antenna kit. Runs on 12VDC vehicle or battery power.



DDF1 Doppler Direction Finder Kit \$169.95

Mad Blaster Warble Alarm

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.



MB1 Mad Blaster Warble Alarm Kit \$9.95

Laser Light Show

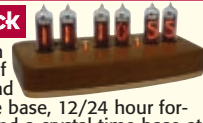
Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.



LLS1 Laser Light Show Kit \$49.95

Retro Nixie Tube Clock

Genuine Nixie tubes popular in the 50's brought back in one of the neatest digital clocks around today! Hand made teak maple base, 12/24 hour format, soft fade-out, auto-dim, and a crystal time base at 20ppm! Tube kits also available.



IN14TM Teak Maple Nixie Clock Kit \$329.95

Water Sensor Alarm

This little \$7 kit can really "bail you out"! Simply mount the alarm where you want to detect water level problems (sump pump)! When the water touches the contacts the alarm goes off! Sensor can even be remotely located. Runs on a standard 9V battery.



MK108 Water Sensor Alarm Kit \$6.95

USB DMX Interface

Control DMX fixtures with your PC via USB! Controls up to 512 DMX channels each with 256 different levels! Uses standard XLR cables. Multiple fixtures can be simply daisy chained. Includes Light Player software for easy control. Runs on USB or 9V power.



K8062 USB DMX Interface Controller Kit \$67.95

HV Plasma Generator

Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.



PG13 HV Plasma Generator Kit \$64.95

Air Blasting Ion Generator

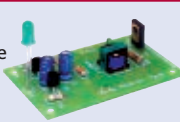
Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.



IG7 Ion Generator Kit \$64.95

Tickle-Stick Shocker

The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.



TS4 Tickle Stick Kit \$12.95

Speedy Speed Radar Gun

Our famous Speedy radar gun teaches you doppler effect the fun way! Digital readout displays in MPH, KPH, or FPS. You supply two coffee cans! Runs on 12VDC or our AC125 supply.



SG7 Speed Radar Gun Kit \$69.95

Tri-Field Meter Kit

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.



TFM3C Tri-Field Meter Kit \$74.95

USB Experimenter's Kit

Get hands-on experience developing USB interfaces! 5 digital inputs, 8 digital outputs, 2 analog I/O's! Includes diagnostic software and DLL for use with Windows based systems. The mystery is solved with this kit!



K8055 USB Experimenter's Kit \$49.95

3-In-1 Multifunction Lab

The handiest item for your bench! Includes a RoHS compliant temp controlled soldering station, digital multimeter, and a regulated lab power supply! All in one small unit for your bench! It can't be beat!



LAB1U 3-In1 Multifunction Solder Lab \$129.95

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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ Cheap Strobe
- ✓ Re-Using Old Transformers
- ✓ Dump Load Calculation

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions.

Send all questions and comments to:
Q&A@nutsvolts.com

PHONO PREAMP

Q I need a simple phono preamp that will boost a ceramic cartridge output. The cartridge has an output of 400 mV and I need an output of 1V. The voltage gain would need to be 2.5 — about a 8 dB gain. It would be nice if it would work with a single supply power supply. Do you have any suggestions?

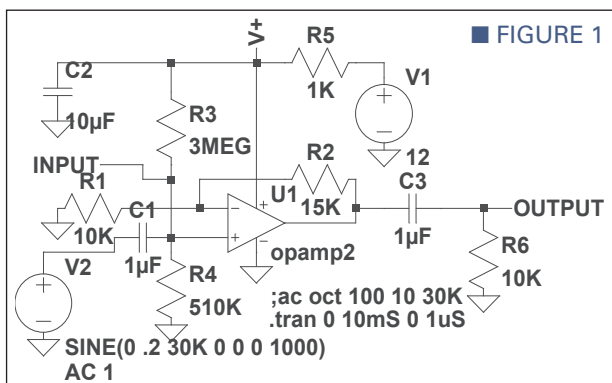
— Jeff Miller

A The ceramic cartridge output is high, so noise in the amplifier will not be a problem. I simulated it with an LT1006 which has a gain-bandwidth of 300 kHz; so almost any single supply op-amp will work. You will need a dual op-amp and double the circuit for stereo. This circuit is quite flat from 30 Hz to 30 kHz and distortion will be low. The venerable LM358 at 15 cents from

Allied is the most economical. It might not work on five volts but is good up to a 30 volt supply. The MC33202 at 95 cents from Mouser would be good for low voltage operation.

The schematic in **Figure 1** is from the simulator. V1 is the power supply which should not be greater than the rating of the op-amp. R5 and C2 comprise a filter to remove any hum that may be on the power line. R6 simulates the input impedance of the amp; if you know that there is a capacitor at the amp input, C3 is not needed. The ceramic cartridge is high impedance and won't affect the bias voltage if C1 is not used. However, I think C1 should stay. Otherwise, there will be two volts bias on the ceramic cartridge which might cause distortion. In fact, it may be a good idea to put a one meg resistor across the cartridge output to insure there is no DC across it.

CHEAP STROBE



Q I need to construct several cheap strobe lights, battery powered (preferably nine volt transistor), duty cycle about one second between flashes. I would appreciate any help or suggestions.

— Bob Haeberle

A For a cheap strobe, the throwaway camera comes to mind. You can get these free at some one hour photo shops; don't bother with the chain stores because they send used cameras to a recycler. An independent photo shop will most likely just throw them away and be glad to get rid of some. I got three from a local camera shop (could have had more). Two cameras were Kodak; one was no name. The Kodak units were made to snap together and came apart easily; the no name unit had two screws to remove the case but the case was broken because it was opened without removing the screws.

When you remove the PCB (printed circuit board), be careful where you put your fingers. I got shocked on the first one and it doesn't work anymore. The flash operates by charging a capacitor to about 300 VDC, then discharging it through a xenon lamp. There is a snap button that activates the charging circuit; you have to hold it down until a neon lamp glows to indicate that the capacitor is fully charged. There will be two contacts operated by the shutter to fire the flash. These contacts will have up to 300V on them and the current — when closed — will be high. I tried a TO-92 triac to take the place of the contacts and it worked! The triac was STMicroelectronics Z00607MA, rated 600V and 0.8

amps RMS. One contact was connected to the battery negative so I connected MT1 to that and MT2 to the other contact which was negative voltage. When I connected the gate through 12 ohms to battery positive, the unit flashed.

In the circuit of **Figure 2**, the snap button is replaced by Q1. The collector connects to the button and the emitter connects to the center contact. It is usually not necessary to remove the button because there will be other solder points to attach a wire. The capacitor takes a long time to charge; the xenon lamp flashes about every 40 seconds. The oscillator is faster than that but if it tries to fire and the voltage is not high enough, it just keeps going until the voltage is high enough. **Figure 3** is a photo of my control circuit and the camera PCB. I could design a circuit to charge the capacitor faster but I have tried this sort of thing before and it is not easy (I wouldn't finish in time for the publication deadline). The only thing salvageable would be the capacitor, xenon lamp, trigger transformer, and capacitor.

THERMOMETER REPAIR

Q I have a RadioShack model 63-1020 dual display indoor-outdoor thermometer. I want to replace the outdoor sensor. I tried using a 1N34 diode but could not get the range needed. The unit runs on one AA battery. Hope you can help.

— Ken Bartone

A In searching the WWW for an answer to your question, I found Phil Stuart who runs www.randomuseless.info. He shows how to change the 63-1020 from degrees F to degrees C, so I sent him an email asking what he knows about the sensor. Phil went so far as to measure

the sensor (it is a thermistor) and match it to Mouser part 871-B57861S503F40 (which costs \$1.60). Also, I found a parts list for the thermometer; the part number of the external sensor is 10584753 and costs \$5.49 plus shipping. The sensor is potted and includes the wires. You can order it at your local RadioShack.

RE-USING OLD TRANSFORMERS

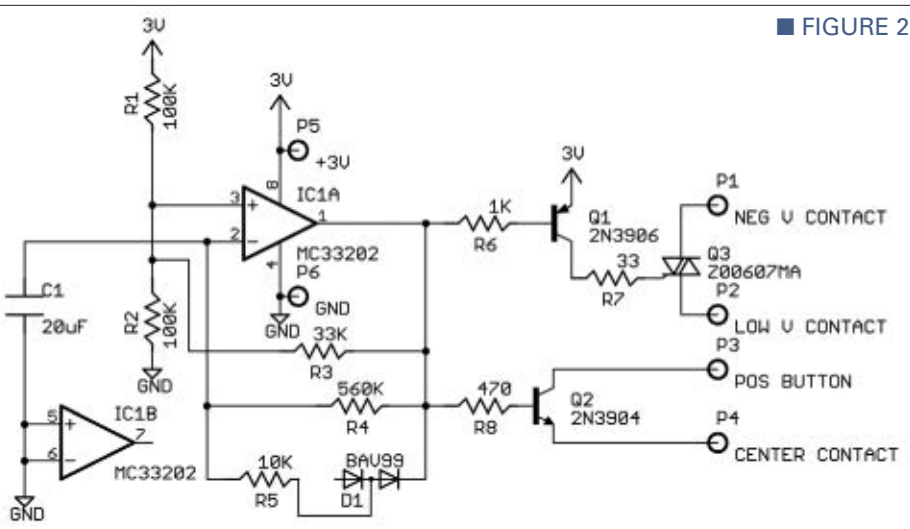
Q As the proud owner of many junk box transformers, I know that finding the current capacity of each winding of a multi-output transformer is about impossible, unless I use the change in resistance of copper to tell me when a winding is getting too hot. I expect that single output transformers must be more easily measurable. I'd like a circuit that would betray the onset of magnetic saturation (or some other relevant parameter) so I can safely use old transformers for my experiments.

I have a Variac, dual channel scope, 1% DVM, and a multitude of resistors, capacitors, and

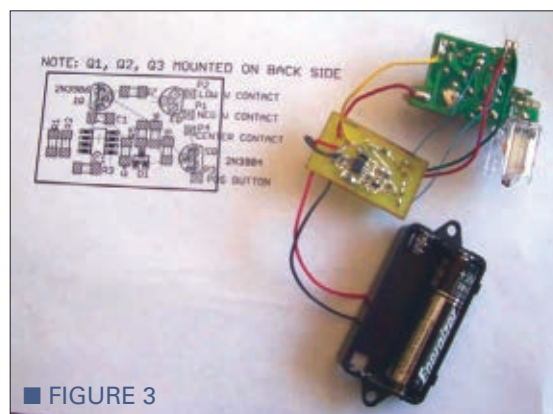
semiconductors. Thanks for your help.

— Chuck

A For a multi-winding transformer, you will be safe if you figure 10% voltage drop under load. Say you have a winding that measures 18 volts RMS open circuit and 10 ohms resistance; 1.8 volts drop will occur with 0.18 amps current. That should be considered maximum for that winding. If any winding is less than 15 ohms, it can't be used as the 120 VAC primary because the inductive current will be too great. Transformers are rated by the volt-ampere capacity (VA). A transformer rated 12.6 volts RMS at two amps has a VA rating of 25.2. Since flux density is the usual limiting factor in transformer design, it follows that a higher VA rating



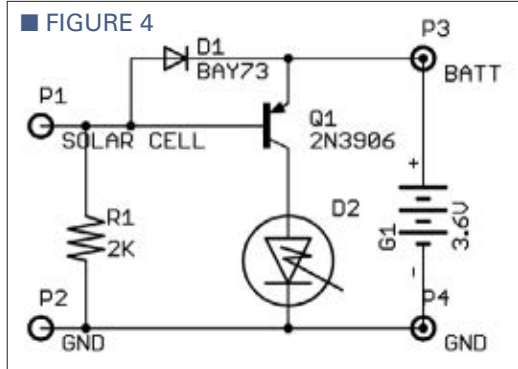
■ FIGURE 2



■ FIGURE 3



■ FIGURE 4

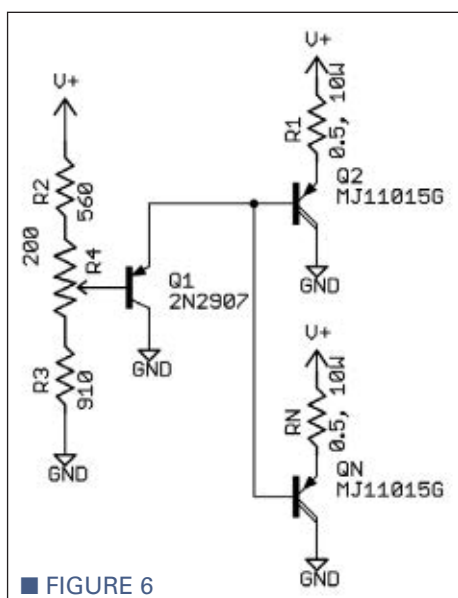


requires more iron; you should be able to weigh a transformer and calculate a VA capability. I weighed some of my transformers that have the VA rating on them and concluded that 20 VA per pound is a conservative number for a 60 Hz transformer.

SOLAR LIGHT

With the current low prices of bright LEDs and basic solar panels, I want to put together a simple system of night lights for my yard. Do you know of a simple circuit that would turn them off during the day? Something that would sense the higher voltage from the solar panel when the sun is out, and thus switch the battery from the LEDs over to the solar panel for charging? Ideally, it would be easily adjustable to really fine-tune when the switch occurs.

— John Chaput



■ FIGURE 6

SOLAR LIGHT PARTS LIST

PART	DESCRIPTION	PART #
SOLAR CELL	4.7 VDC, 50 mA	1928142
R1	2K, 1/8W	691171
D1	100V, 0.5A	655613
Q1	2N3906 OR PN2907	805597
D2	LED, White, T1-3/4, 20 mA	334773
BATTERY	1.2V, 700 mAh (1 OF 3)	261657
BATT. HOLDER	FOR 3 AA CELLS	216144
All part numbers are Jameco (www.jameco.com)		

■ FIGURE 5

The circuit of **Figure 4** is as simple as I could make it. R1 turns on Q1 to light the LED. I did not use a series resistor because the LED forward voltage is so close to the battery voltage, the internal resistance will regulate the current. The light will dim as the battery runs down but at 700 mAh and 20 mA, it will last all night and then some. When the sun shines, the solar cell voltage will shut off Q1 and charge the battery through D1. The charging current may be more than needed in bright sunlight but I don't think it will damage the battery. The battery may not fully charge on a cloudy day. I did not include a circuit to turn the transistor off before the solar cell is able to charge the battery because it would have greatly increased the complexity. **Figure 5** is the parts list.

You can buy a box of six lights at Home Depot for under \$50; that may be the most cost-effective solution.

DUMP LOAD CALCULATION

I have a small 12 VDC renewable energy system in my home. It consists of a few solar panels, a small wind turbine, and soon a small hydro electric generator. I use a diversion type regulator that is rated for 120 amps. I can set the voltage to 13.8V and the regulator will divert the excess current to a dummy load. I currently have the system connected to two 60 amp water heater elements. I have prototyped a circuit that will detect when the temperature

load can be made with solid-state devices like PNP transistors. I found a schematic for a small heater using TIP2955 transistors mounted on an aluminum plate. I want to build something like that to handle 150–160 amps safely. I don't care if the plate is large; like two feet by three feet if needed. I want to use PNP transistors so the case is tied to negative ground. I would also like some small muffin fans included.

After looking around on the Internet, I came across a 2N6287 power Darlington transistor in a TO-3 case. The base current is only 0.5 amps and it can dissipate 160 watts. Even if I have to use 30 of these, it will be cheaper than \$400 worth of resistors — plus, it is something I can build myself and that is always good. I also need some help on the square inches of, say 1/8" thick, aluminum plate needed per transistor to dissipate the heat.

I would like to know if you think this would be a reliable dump load and can you help me with the design/details? Or, do you have a better idea for this application?

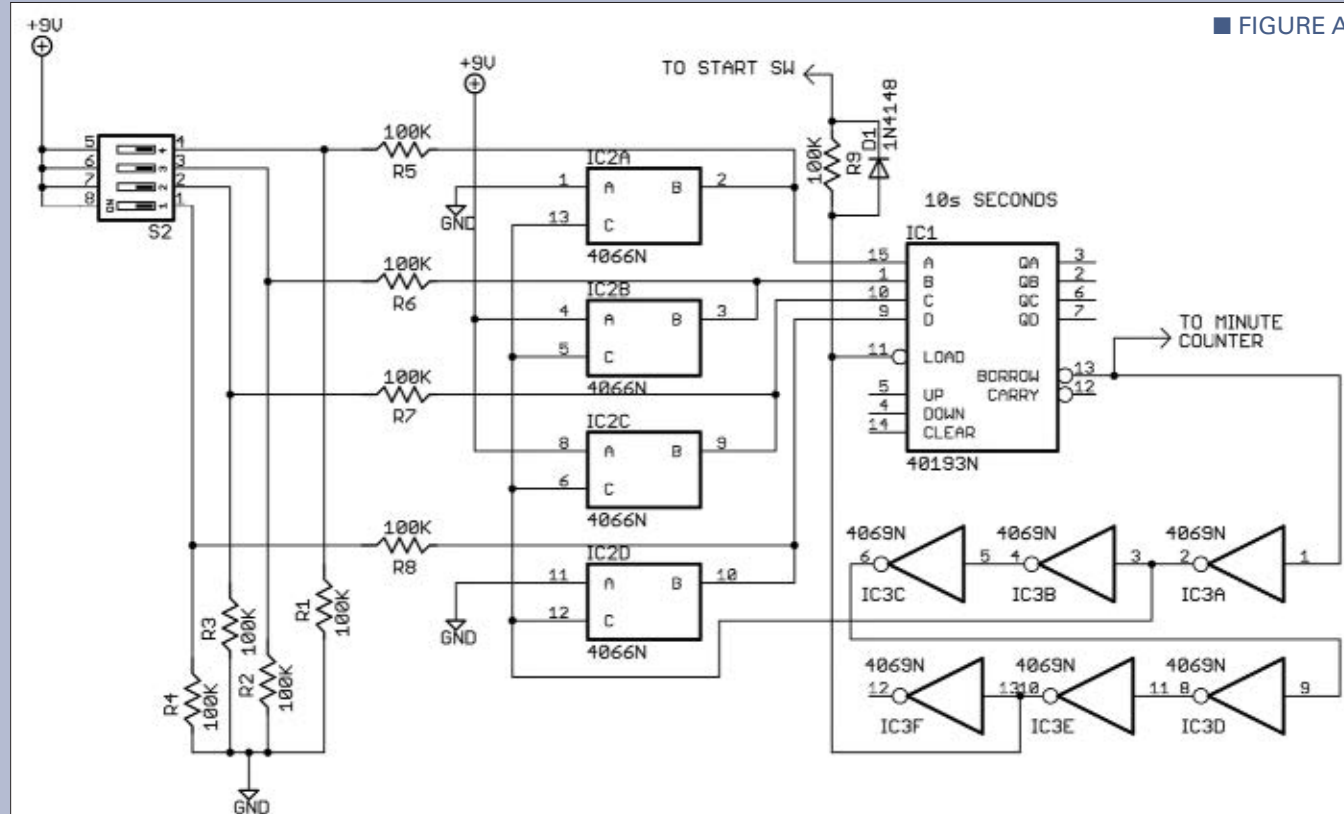
— Tim Henley

Your idea will certainly work, whether it is cost-effective remains to be seen. I found a better transistor. (MJ11015G from Mouser) for about the same cost of \$2.68 each in a quantity of 25. It is rated 200 watts with a junction temperature of 200 deg C. **Figure 6** is the basic circuit. An emitter-resistor is needed to distribute the current evenly among the transistors. Each transistor is designed to draw 4.5 amps so 33 will be needed for 150

of the water gets to 120 degrees and switch the current to some resistors in open air. Resistors that I have found cost \$200 for 60 amps; \$400 for 120 amps is totally ridiculous!

Here is my question: I want to know if a dump

■ FIGURE A



MAILBAG

Dear Russell:

In the Jan 2010 issue, reader Dusan had a question about grounding and PoE (Power over Ethernet). The reader wanted to know if it was okay to "connect the PoE ground to the existing power supply ground."

The answer is NO. In my experience, PoE circuits take after the old Bell System practice of having the positive side as the ground and the "supply voltage" being -48V. (I think this had something to do with preventing corrosion should the circuit be exposed to weather.)

In the rare cases that I've seen the PoE negative side DC rail connected to "ground," smoke has resulted. It's best to think of PoE circuits as a positive-ground system with a -48 VDC power rail.

— Mark Jarvis

Response: Thanks for the feedback Mark; but if the POE supply provides isolation (switching supply with transformer), grounding is not a problem.

PC Board Current Capacity, Jan



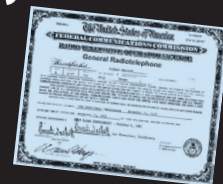
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2010, page 25. I got a lot of feedback on this one! Many people sent charts and calculations but the best (in my opinion) is this link from Rick L. and Charles Ryberg: <http://circuitcalculator.com/wordpress/2006/01/31/pcb-trace-width-calculator/>.

Dear Russell:

Re: February issue, Countdown timer, page 18. If I read the schematic correctly (which I may not have), the minutes display would actually be hundreds of seconds. I tried to think

of a simple way to preload 60 on the tens of seconds when borrowing from the minutes, but it got very complicated very quickly.

— John Orndorff

Response: You are so right; I completely spaced it. When the 10s counter hits zero, it goes to nine instead of six. My solution to that problem is Figure A. When the borrow output goes low, the analog switch is turned on, which loads six into the counter. The analog switch

is able to overcome any number that may be loaded in the program switch. At startup, the borrow output is probably low causing six to be loaded, but then the borrow output goes high and the program number is loaded (providing the start switch is closed). The hex inverter is used to delay the load command until after the data is stable. Otherwise, the loaded number might not be correct.

Thanks for bringing this to my attention.

amps. The emitter-resistor dissipates 10 watts so that is 330 watts not in the heat-sink. Now I need to calculate the transistor junction temperature to see how much safety margin there is. I don't want to operate near 200 deg C because the reliability will be poor and the failure mode is a short circuit (which could result in transistors popping all over). The junction temperature is found from:

$$T_j = P \cdot (R_{jc} + R_{ch} + R_{ha}) + T_a$$

where:

P = Power dissipation in watts

R_{jc} = Junction to case thermal resistance in deg C/watt

R_{ch} = Transistor case to heatsink thermal resistance in deg C/watt

R_{ha} = Heatsink to ambient thermal resistance in deg C/watt

T_a = Ambient temperature

R_{jc} is given on the datasheet as 0.87 deg C/watt

I found a chart (Figure 7) of the thermal resistance of sheet aluminum. I was not able to find the thermal resistance of a TO-3 case to heatsink, so I did an experiment. I had a 9.5x12 inch sheet of aluminum diamond plate (hardware store item); I mounted an unknown PNP transistor with heatsink compound and 4-40 screws, and tightened it as much as possible (see Figure 8). At 45 watts, the case temperature was 84 deg C and the heatsink was 81 deg C. I figure this is 3/45 = .07 deg C/watt. The area of my heatsink is 736 sq cm which I find on the chart in Figure 7 to give R_{ha} = 1.5. The ordinate is not labeled but I assume it is deg C/watt. Ambient temperature is nominally 25 deg C, so:

$$T_j = 52 \cdot (.87 + .07 + 1.5) + 25 = 152 \text{ deg C}$$

This is for the plate mounted vertically in still air. If you blow air on it, the temperature can be reduced considerably or you can use a smaller heatsink, depending on your need for reliability. The 0.5 ohm resistor is

Mouser part number 280-CR10-0.5-RC; cost is \$0.47 per 10.

INEXPENSIVE DRAFTING SOFTWARE

Being a newbie, I am trying to identify an electronic/mechanical drafting program to buy and use. For the projects I will doing, I want to be able to draft out a block diagram for the components, a schematic for the electrical diagram, a flow chart for programming the microcontroller, and capture all the notes I would like to post. I just have not seen any software that jumps out at me. Can you please give me a recommendation(s)?

— Mr. Lynn Wyatt

I have very limited experience with that kind of software; I have been using AutoCAD's Autosketch v.2.1 for 15 years and have built up a library of electronic parts plus other parts. I have used it for schematics and layouts,

mechanical layout, and architectural design. The newest version is 10 and costs \$235 but version 9 is available on eBay for under \$50. Perhaps readers will have recommendations for good, inexpensive software (something that you have used and like, please). **NV**

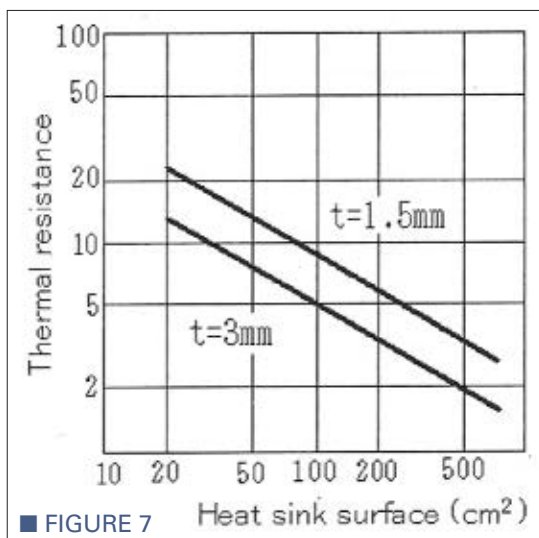


FIGURE 7



FIGURE 8

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This Lambertian pattern emitter
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TDK #ZCAT1518-0730-BK.
For cables up to 7mm
(0.27") dia. Case has an
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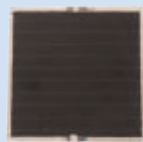


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Output: approximately 3 Volts
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BY BEN GRAHAM

BUILD THE VEX 2-DIGIT SCOREBOARD



If you're a sports fan (playing sports that is), then you've probably wished at some time that you had a way to keep track of goals while practicing or competing. Whether you're practicing hoops at the gym or on the driveway, the VEX two-digit scoreboard will keep track of the number of shots you've made. This article will deal with just the construction of the scoreboard so it can be used with any sport or anything that needs a big, two-digit display.

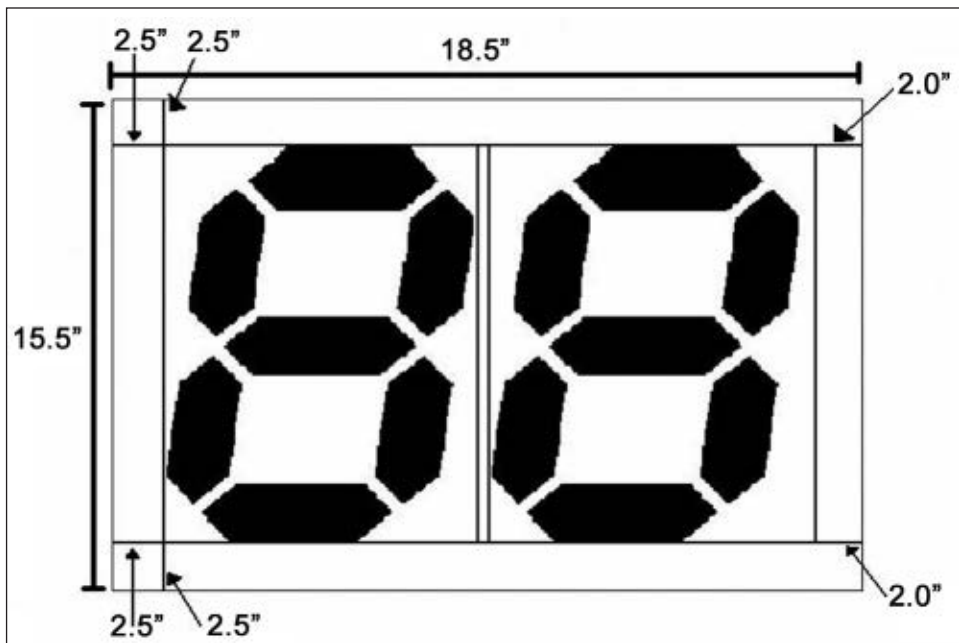
Step 1 - Making The Front Panel

1A - Cut out a rectangle 18.5" by 15.5" from the (a) foam core board, (b) cardboard, and (c) black posterboard. Download and print the template from the *Nuts & Volts* website at www.nutsvolts.com. Then, cut out

the black segments leaving the open area as a stencil.

1B - Tape the black cardboard lightly along the edges, on top of the foam core board. (*This is only temporary.*) This is so you only have to cut once, and everything will line up perfectly. From the bottom of the board, measure 2.5 inches up and draw a very light line across the black cardboard. This will be the base line for your template.

1C - Lay the template on this line and move it 2.5" from the left side. Using the template as a stencil, draw each of the seven segments on the cardboard. Move the template 2" from the right and repeat the process. See **Figure 1**.

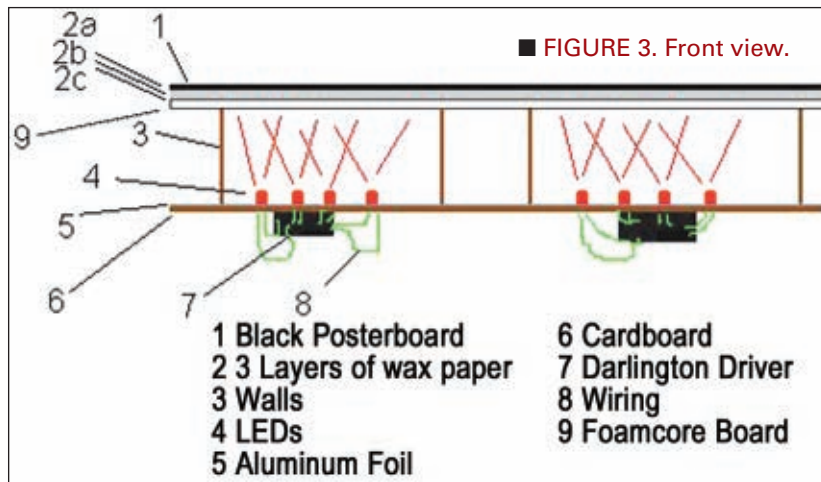


■ **FIGURE 1.** These are the dimensions of the scoreboard.

***Note:** The middle section of the scoreboard is an overlap, not a gap (if you were to use two different templates).

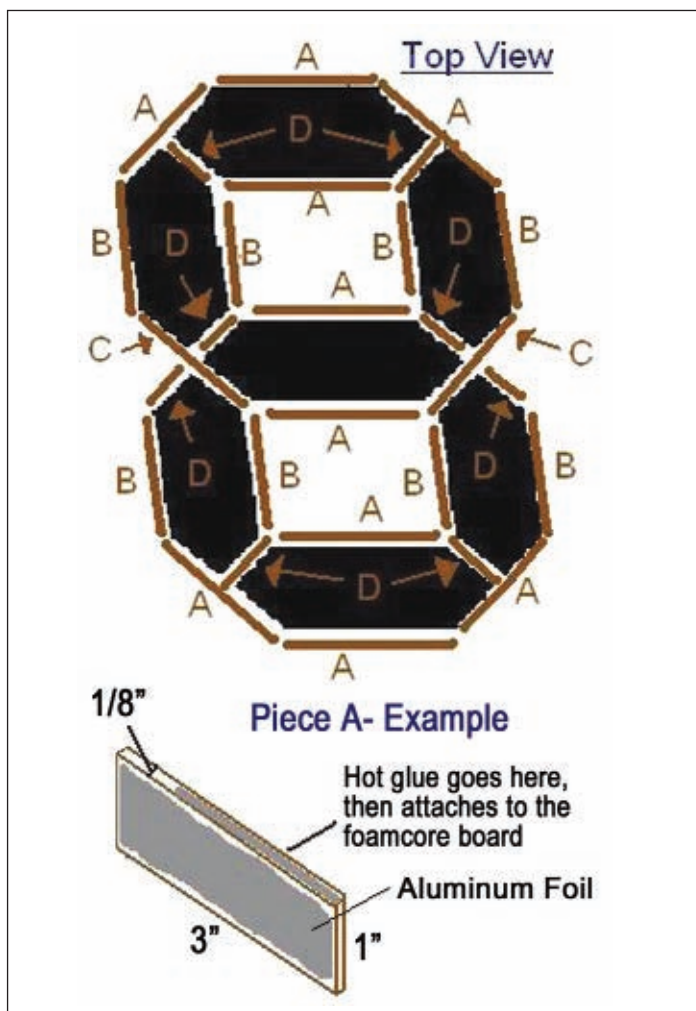
Step 2 - Cutting Out The Segments

Now that you have all your lines drawn on the cardboard, it's time to cut. Using your X-Acto knife, carefully cut through the black and foam cardboard. The slower you go, the better it will look when you're finished. It may help to use your ruler or straight edge and line it up along the lines. Remember any vertical lines are slightly slanted. (*Don't cut perpendicular to the top or bottom of the poster board.*) Once you're done cutting, remove the tape that held the black and foam core boards together, but do this carefully so you don't tear the black cardboard.



Step 3 - Creating The LED Compartments

This is the most time-consuming step. Here, we are trying to create small compartments to hold the LEDs. This step is what gives the scoreboard its depth.



■ FIGURE 2. Diagram of each wall needed to create the individual compartments.

3A - Cut out the following pieces from the cardboard; all of them are 1" wide (see **Figure 2**):

Size A:	3"	Need 10 pieces
Size B:	2.5"	Need 8 pieces
Size C:	2.0"	Need 2 pieces
Size D:	1"	Need 8 pieces

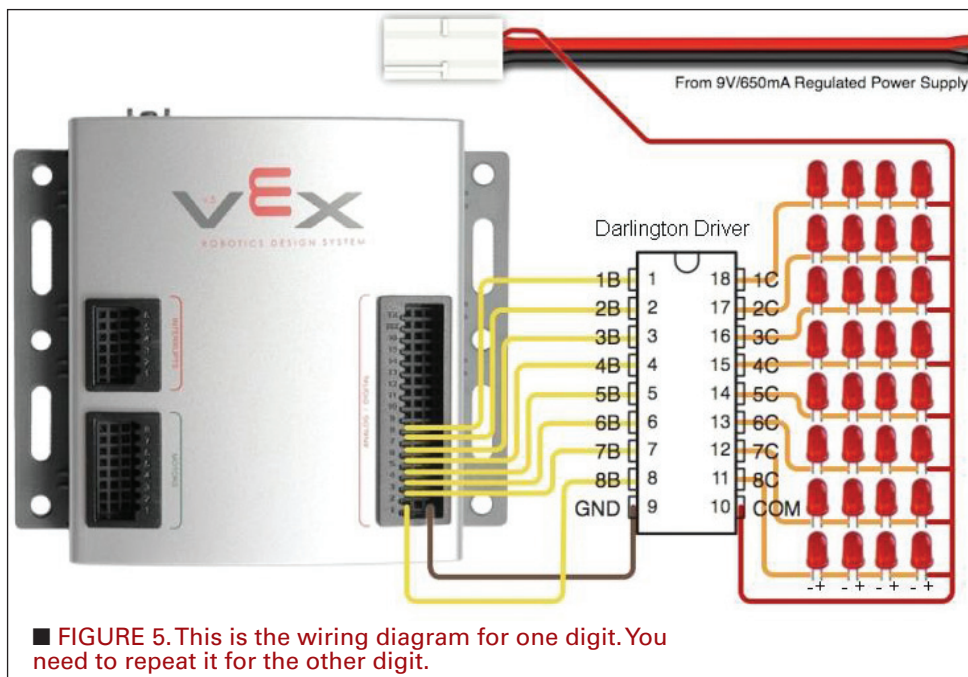
3B - Attach aluminum foil to one side. (*Double-sided tape works great or 3M spray adhesive.*) This is going to give each segment a very full look. Don't forget that some of the little pieces will need both sides covered in aluminum foil since they serve as a wall for more than one segment.

3C - Once this is done, it is time to glue. Make sure that the digits are slanted to the left. Glue the walls onto the foam core board at the thinnest part of the wall. (See **Figure 2** again.) Repeat this process for the second digit.

3D - Tape three pieces of wax paper across the top of the digits on the foam core board; this will diffuse the light from the individual LEDs and create a fuller look. Then, glue the black cardboard over the wax paper to the foamboard. See **Figure 3**.



■ FIGURE 4. Example of the LED setup.



4C - Cut two slits vertically where you made the surface holes in the aluminum foil. Stick the legs of the LEDs in these slits and wire according to the diagram in **Figure 5**. Put the Darlington driver into a general-purpose IC circuit board to make it easier to solder to.

4D - The last *electronic* step is to solder the RC battery pack connector to the 9V regulated power supply. The very last step is to glue the foam core board and the cardboard with the LEDs on it together. The final product assembly should look like **Figure 3**.

The scoreboard could be mounted inside a wood frame to give it more durability, but that's up to you.

Conclusion

Step 4 - Electronics

Now that the basic frame of the scoreboard is complete, it's time to install the LEDs and wiring.

4A - Tape or glue a big piece of aluminum foil across the first piece of cardboard that you cut out and using the black cardboard piece as a template, trace all the segments of the two digits onto the aluminum foil.

4B - In each one of the 14 segments, mark four evenly spaced dots where the LEDs will go. To prevent the LEDs from shorting out, cut and remove a small square of aluminum foil behind each LED. *Don't cut deep; just scratch away the surface of the foil using an X-Acto knife.* Now you're ready to install and wire all of the LEDs in each segment.

Now you're finished constructing the VEX scoreboard. There are endless possibilities when it comes to programming what you want to display. All you need to do is use digital outputs to turn on and off each segment to create different numbers. Besides using the scoreboard to keep track of baskets or goals, you could also program it to count down, so you can practice those last second buzzer beaters!

I programmed the VEX MCU using a simple C code editor called EasyC which works with the VEX system. When I press a joystick up, it adds one to a variable. Then, using a look-up table it converts the variable to a decimal number and uses it to display a digit.

For counting basketball shots, the system I'm going to

use consists of a few different sensors. I plan to put an ultrasonic sensor below the net to keep track of the number of made shots. For missed shots, I'm going to attach an accelerometer to the back of the basket to measure the movement from the ball hitting the backboard. Then, using some simple math, the scoreboard could display some cool data such as made shots, missed shots, shooting percentage, and much more. Use your imagination to invent your own method.

Have fun! **NV**

PARTS LIST

QTY DESCRIPTION

Electronics

QTY	DESCRIPTION	PART NUMBER
56	Red LEDs	SparkFun.com part #COM-00528
2	Darlington driver eight-channel	SparkFun part #COM-00312
1	Dual general-purpose IC PCB	RadioShack model 276-159
1	Wall adapter power supply 9 VDC 650 mA	SparkFun part #TOL-00298
1	RC 7.2V battery pack connector repair kit	RadioShack #23-444

Materials

Foam core board - You can get this at almost any drugstore or arts and crafts store.

Cardboard - Staples item #426426 (five pack). You probably will only need one or two of these boxes or any other cardboard of similar quality can be used.

Black posterboard - Office Depot item #858430 (five pack). You only need one of the five.

Seven-segment display template - You can download this at www.nutsvolts.com.

Wax paper

Aluminum foil

Tools Needed

Soldering Iron

Solder

Scissors

X-Acto Knife

Tape

Hot Glue Gun

Note - This article assumes that you already have a VEX development kit. If not, check out www.vexrobotics.com

NEW

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- SOFTWARE
- GADGETS
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PRODUCTS

TRIGGER AND DECODE PACKAGES FOR MIL-STD-1553



LeCroy Corporation's new 1553 TD (trigger and decode) package provides all the tools needed to analyze and debug the MIL-STD-1553 protocol bus. LeCroy's unit provides both a transfer level view to enable a higher level of understanding of messaging and timing, or a word level view to debug at the individual bit level.

Color-coded overlays on various sections of the protocol decode are used by 1553 TD for a visual display that is easy to understand. This feature (exclusive to LeCroy) is intuitive for experienced engineers and is especially useful for users new to the MIL-STD-1553 standard. In addition, decode information condenses or expands depending on the timebase/zoom ratio setting, simplifying both routine verification and complex troubleshooting. Engineers can choose to decode into hex or binary.

The 1553 TD trigger solution provides tools to isolate specific errors in the protocol to quickly pinpoint the area causing the most problems. A timing trigger mode allows the user to quickly find timing violations of both the intermessage gap time (IMG) or the response time

between a BC and RT, or from a RT to another RT.

For more information, contact:
LeCroy
 Tel: 1-800-5LeCroy
 Web: www.lecroy.com

USB BENCHTOP MULTIMETER



B&K Precision has launched their newest bench-top multimeter — Model 2831E — which is excellent for applications in education, service and repair, manufacturing, or any application where affordable, accurate, and reliable measurements are needed.

The 2831E offers a remarkable accuracy of 0.03%, a digital dual display for viewing two measurements simultaneously, a fast measurement rate of up to 25 readings per second, threshold settings for quick Pass/Fail testing, plus the ability to download measurement values to a computer via a USB interface using SCPI protocol.

This bench-top DMM provides true RMS precision with a 20,000 count display. Its AC+DC capability captures any DC effects within the measured voltage or current for the most accurate results. The front panel of the 2831E has a bright display and tactile pushbutton control with easy-to-follow second function commands.

The 2831E provides all expected measurements of AC and DC voltage to 750V and 1,000V, respectively, AC and DC current to 20A, resistance, frequency, and continuity tests.

For more information, contact:
B&K Precision
 Web: www.bkprecision.com

PIC32MX4 MULTIMEDIA BOARD



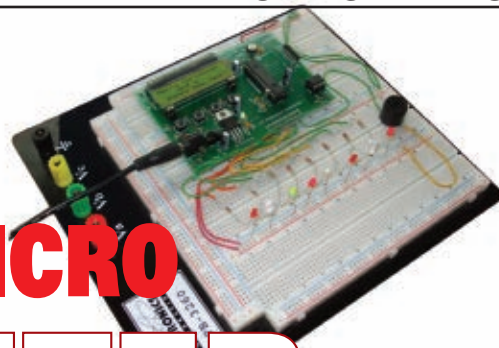
MikroElektronika introduces their new PIC32MX4 MultiMedia Board as an addition to its PIC32 development tool product line. The MultiMedia Board is a compact development system for advanced user interface applications in development and testing.

This tool provides a complete, high-quality, multimedia development platform supporting PIC32MX4 devices. It is also compatible with the latest PIC32MX5/6/7 series and has many multimedia features for users to develop advanced graphical, audio, memory, and storage applications using popular components.

For more information, contact:
mikroElektronika
 Web: www.mikroe.com



USING A 128x64 GRAPHICS DISPLAY WITH YOUR 16-BIT MICRO EXPERIMENTER



We've discussed a number of features on the 16-bit Micro Experimenter since introducing it in the Dec '09 issue. This time, we will extend Experimenter applications with graphics. We are all familiar with character-based LCD displays. They have been around for quite some time. But what if you could have both characters as well as graphic displays at the same time? Using graphics enhances the user's experience. We'll show you how easy and inexpensive this technology can be with the 16-bit Micro Experimenter. This article introduces a low-cost hardware solution and 'C' software library that works with our 16-bit device. **Figure 1** shows an example of this graphics capability.

■ **FIGURE 1.** Experimenter with Graphics display.

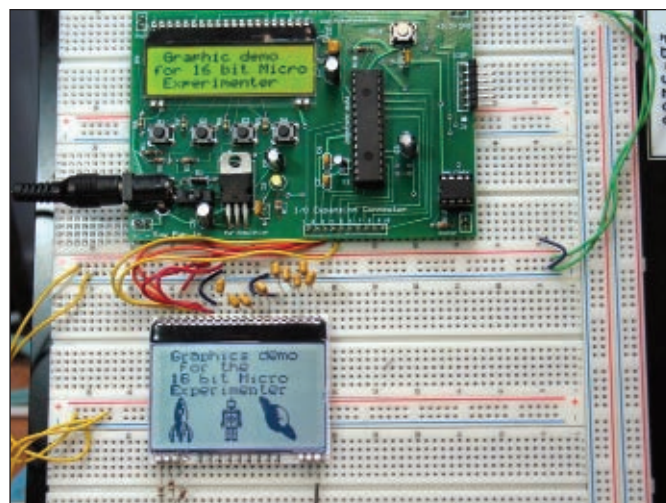
Introducing the EA DOGM 128x64 Graphics Series LCD Display

We will be using the EA (electronic assembly) DOGM Graphics series display. The display has a matrix of 128 horizontal pixels by 64 vertical pixels, for a total of 8,192 pixels. This display provides a significant capability for displaying pictures, graphics, and text. Designed for commercial hand-held devices, it is extremely compact with a large viewing area. The +3.3 VDC display is a perfect addition and is easily mountable onto a solderless breadboard.

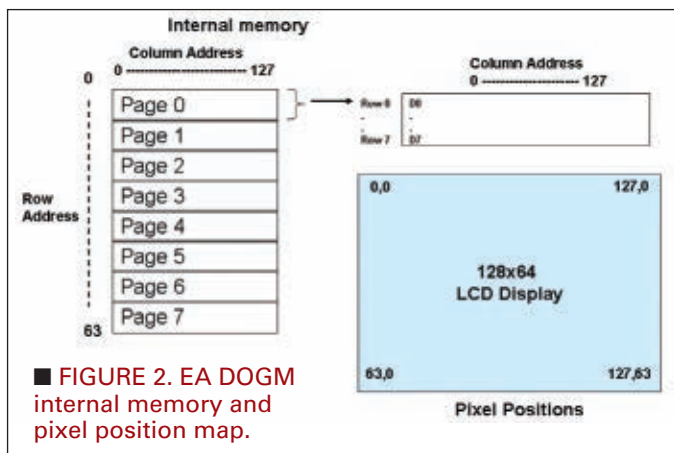
A good choice in the EA series is the DOG128W-6 display when used with the white backlight EA LED55X46-W. This combination creates a monochrome display of black pixels on an illuminated white background. The EA LCD display and backlight modules are configured as a single unit. The DOG128W-6 display plugs in and sits on top of the backlight LED55X46-W. Both parts are soldered together and are then plugged in as a complete assembly.

Hardware and Interfaces

The DOGM has internal memory to support each of the 8,192 pixel states. A block diagram of its internal



memory is shown in **Figure 2**. This internal memory is organized as eight pages of 128 bytes each for a total of 1,024 bytes (8,192 bits). Each bit in the row corresponds to a unique column or horizontal (display pixel) x position. There are 64 rows, so selecting a row corresponds to a unique vertical y position of the pixel on the display. **Figure 2** is marked with the individual pixel addresses (x, y) representing the four corners of the display for a pixel reference map. Setting or resetting a bit for a particular pixel will turn it on or off during display.



Control of the display is through Synchronous Peripheral Interface (SPI) for initialization, setting pixel contrast, pixel addressing, and pixel on/off. The use of SPI really simplifies interconnection between the Experimenter and the display. Only a few control lines plus power and ground are needed.

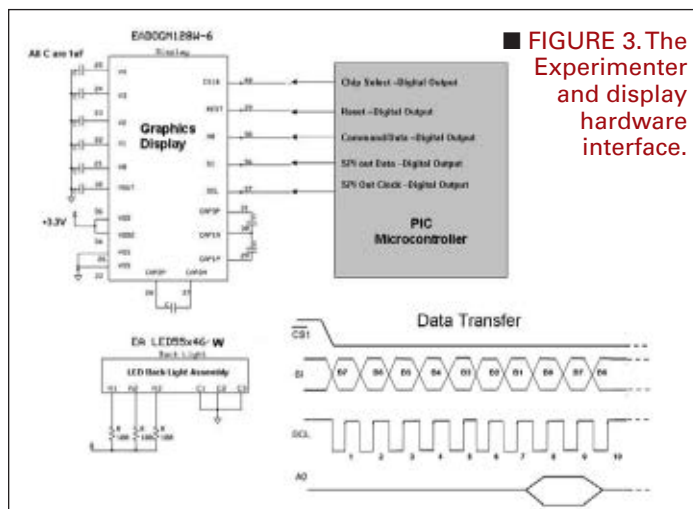
To support the internal workings of the display, a total of nine 1 μ F external capacitors are needed as shown in **Figure 3**. The backlight which mounts under the display requires three 100 ohm resistors to current-limit the three integrated LEDs within the backlight. Make sure when mounting the display on the backlight to remove all the protective films, labels, and papers that are on the components. If left on (and the units are soldered together), they will form a permanent shadow and will block the light. This takes away from a clean display.

A timing diagram for the SPI is also shown. The SPI data out is clocked eight bits at a time. All communication between the Experimenter to the display is one way — only the Experimenter talks. The command or data indication (A0) must be valid during transfer. The EA DOGM brochure lists a table of all the programming commands to properly initialize the display. The 'C' Graphics library does this as well as handles all communications with the display.

Introducing the Graphics Library

To help use the capabilities of the DOGM, a Graphics library is included. This library provides an Application Programming Interface (API) that is really just a bunch of C functions and rules. We will discuss each of these with examples. The library lets you draw lines, bars, circles, triangles, rectangles, and bitmaps, plot data, and output text. These parts of the library API are the graphic primitives. However, in order to use these primitives a lot of low level drivers are required.

Most of these low level drivers function when the primitives are actually drawing, with the exception of initializing the SPI and display — this has to be done by you. The library was written using the Microchip PIC24F C compiler and occupies about 6,018 bytes of Flash and

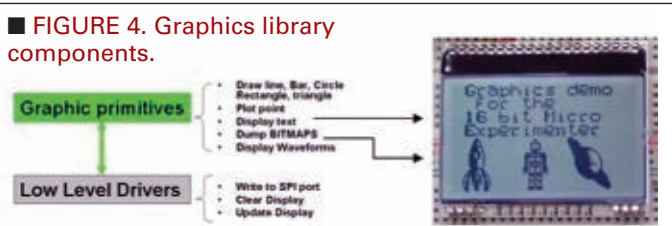


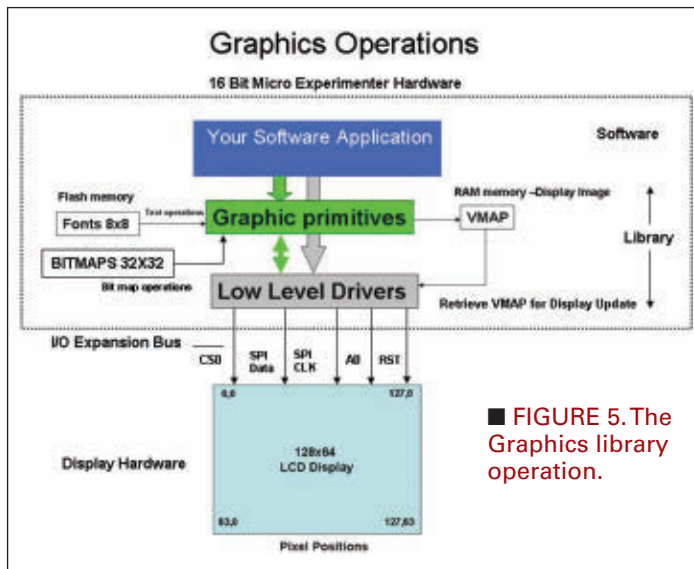
1,264 bytes of RAM. The library is fully contained in three files: Font.h (which contains the bit images for the different character fonts); Graphics.c (the library source code); and Graphics.h (a list of library functions for main code reference).

These must be included in the project and the FONT.H and GRAPHICS.H must appear in the MAIN code using the compiler directives `#include FONT.H` and `#include GRAPHICS.H`. A GRAPHICDEMO project is available from the *Nuts & Volts* website at www.nutsvolts.com to experiment with and use as a template for applications. The library assumes that the Experimenter I/O expansion bus is configured for SPI and digital control outputs. This I/O programming is accomplished at the beginning of the MAIN code in GRAPHICDEMO.

The VMAP, Bitmaps, Font, and Graphics Library Operations

There are several aspects in using the library to be aware of. The library requires — and sets up — a dedicated RAM area within the Experimenter PIC24F designated as VMAP. It is here where all the drawings occur prior to display. The VMAP RAM area is a C array that is configured as a linear memory map 128 bytes x 8 bytes, representing all pixels on the display. VMAP contents are manipulated using the graphic primitives and then dumped onto the display for a drawing or screen presentation. The VMAP is used to do the drawing and then the low level driver "dumpVmap ()" is used to transfer the contents to the display.





■ FIGURE 5. The Graphics library operation.

```
clearScreen(); //clear display screen
AT( 0, 2 ); // position character cursor 1st column 2nd row
putsV( " Random Line" ); // output string to VMAP
AT( 0, 3 ); //position character cursor
putsV( " Demonstration " ); // output string to VMAP
dumpVmap(); // dump VMAP to display
```



■ FIGURE 6. Text display.

```
clearScreen(); //clear screen
AT( 0, 0 ); //position cursor top left corner
putsV( " 8x8 Font" ); //output string
AT( 0, 1 ); // position cursor next row
putsV( " Demonstration " ); //output string
AT( 0, 3 ); //position cursor next row
putsV( "0123456789"); //output string
AT( 0, 4 ); //position cursor next row
putsV( "ABCDEFGHIJKLMNPOQRSTUVWXYZ"); //output string
putsV( "abcdefghijklmnopqrstuvwxyz"); //output string
putsV( " !@#$%^&*()+="); //output string
dumpVmap(); //dump VMAP to display
```



■ FIGURE 7. FONT display.

When writing text, the library makes use of a font array that is organized as 8 x 8 pixels for each character that is drawn in VMAP. The font supports all printable characters, numbers, and special characters like quotes, commas, etc. Likewise, when drawing bit images or icons the library uses the available bit images that have been included within the project as "bitmap.h" files. These must include a "# include" directive for each bit image in the

MAIN code. It is recommended to look at the GRAPHICDEMO project to get a better idea of how this works. There are a large number of bit images already provided.

Display Initialization and Refresh Using the Library

There are several library functions that are used to initialize the display, clear it on demand, and dump or "refresh" the contents of VMAP onto the display for presentation.

- **initSD ()** – Initializes the SPI port to communicate to the display, initializes the display for graphics, and clears it of any random pixel content (display comes up blank).
- **clearScreen ()** – Clears the VMAP memory first and then dumps these contents onto the display. Use this to begin any new display screen presentation.
- **dumpVmap ()** – Dumps the current contents of VMAP onto the display. The idea is once the screen is finished in VMAP, it transfers it to the display for user presentation. This function performs that operation.

Outputting Text Using the Library

Outputting text is really simple. An important rule to remember is to position the cursor to a legitimate character position prior to outputting text. Let's discuss "legitimate" character positions. Since the library uses an 8 x 8 bit font for each character and the display has 128 x 64 pixels, there is a total character display capability of 16 columns by eight rows of character text. The library accepts a column value (x between 0-15) and row value (y between 0-7) for text placement. Let's review some important functions and give some examples. Keep in mind that the 0,0 cursor position is the top lefthand corner of the display.

- **AT (x, y)** – Position character cursor to x, y position of VMAP.
- **putsV (string)** – Outputs the string starting at the current character position. If the string length extends beyond the maximum column, the text wraps around to the next row.

Figure 6 is a code example for the Random Line Display. A more challenging example that displays the entire available character font in the library on one screen is shown in Figure 7.

Outputting Bitmaps Using the Library

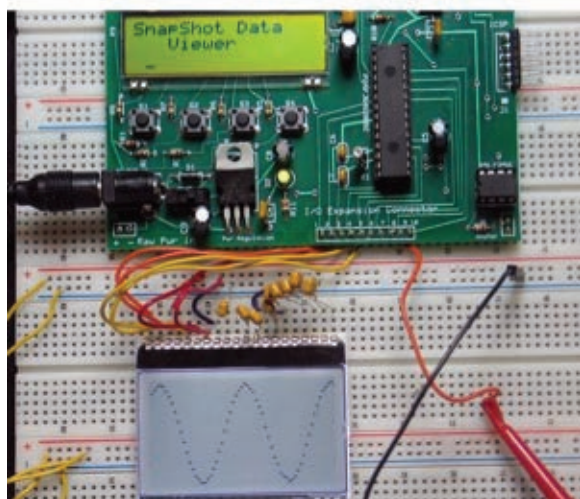
Outputting bitmaps is as easy as outputting text using the library. A bitmap at 32 x 32 pixels is just a large font (remember our fonts are 8 x 8). A particular bitmap has to

```

while (1) {
    clearScreen();

    for ( i=0; i<128;i++)
    {
        temp[i] = readADC( pin9);
    }
    plotSignal(temp, 128,0,0);
    dumpVmap();
    big_delay();
}

```

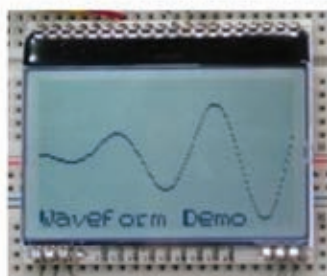


■ FIGURE 12. The Snapshot viewer-display shows incoming 3 kHz sine wave.

```

clearScreen();
plotxsinx();
AT( 0, 7);
putsV( "Waveform Demo");
dumpVmap();

```



■ FIGURE 10. Waveform display.

be included as a "bitmap.h" file in the project and referenced in the MAIN code using a "#include directive." Within the demo, there are up to 18 different bitmaps (these are focused on a Sci-Fi genre with rockets, planets, robots, and satellites).

The basic library drawing function is:

- **drawbitmap32x32 (bitmap, x, y)** — This draws the designated bit map to location x,y of VMAP. In this case, x,y are not character positions but actual pixel based x and y positions. The range of x is 0-127 and y is 0-63.

```

clearScreen(); //clear display screen
AT(0,0) //position cursor top left corner
putsV( "32x32 bitmaps"); //output string
//stack up 4 bitmaps in a row on display round 3
drawbitmap32x32 ( &bitmapspacestation,0,20); //space station bit map at 0,20
drawbitmap32x32 ( &bitmapspacecraft,32,20); //spacecraft bit map at 32,20
drawbitmap32x32 ( &bitmapsaturn,64,20); //saturn bit map at 64,20
drawbitmap32x32 ( &bitmapsplanet,96,20); //planet bit map at 96,20
dumpVmap(); //dump VMAP to display

```

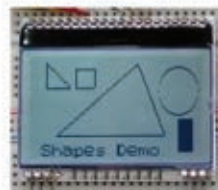


■ FIGURE 8. Bitmaps.

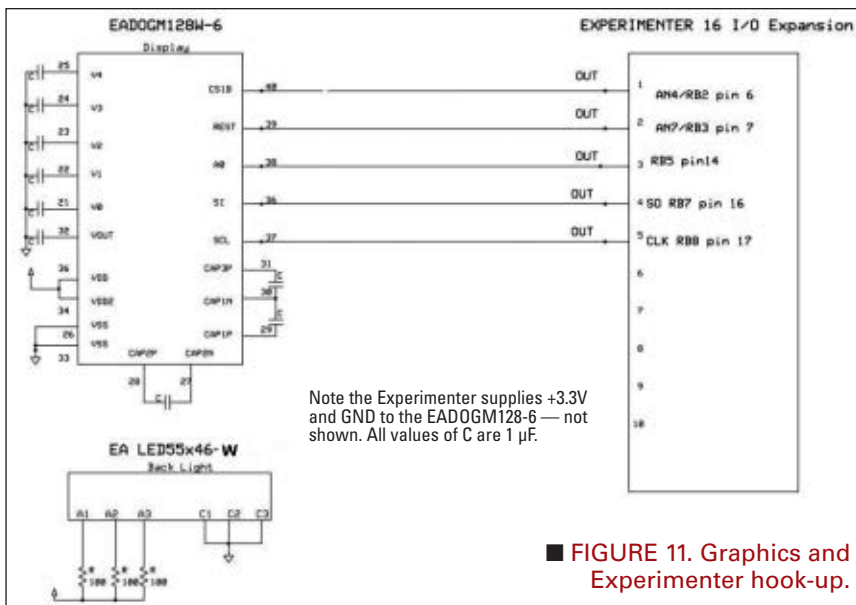
```

clearScreen(); //clear screen
Triangle (80,5,100,50); //draw triangle
rightTriangle ( 12,4, 30, 20); // draw small right triangle
Rectangle (34,8,48,20); //draw rectangle
Bar ( 110,40,120,60); //draw small bar below it
Circle ( 110,22,15); //draw circle
AT( 0, 7); //position character cursor
putsV( " Shapes Demo"); // output string
dumpVmap(); // dump VMAP to screen

```



■ FIGURE 9. Shapes.



■ FIGURE 11. Graphics and Experimenter hook-up.

An actual code snippet used for the first display on the left is shown in **Figure 8**.

Outputting Lines, Triangles, Circles, Bars, and Rectangles Using the Library

Displaying geometric shapes and lines is also straightforward but it does require math functions within C to accomplish this. No worries though. The PIC24F

compiler comes with a Math library and it is used with the Graphics library automatically. Here are the drawing functions of interest:

- **line (x0, y0, x1, y1)** — Draws a line from x0,y0 to x1,y1 in VMAP.
- **Rectangle (left, top, right, bottom)** — Draws a rectangle using top lefthand corner x,y to bottom righthand corner x,y in VMAP.
- **Circle (x, y, radius)** — Draws a circle of radius around center point x,y in VMAP.
- **Bar (left, top, right, bottom)** — Does the same as a

rectangle but fills it in.

- **Triangle (top-x, top-y, right-x, right-y)** — Draws an equal sided triangle from apex x,y to right x,y.
- **rightTriangle (top-x, top-y, right-x, right-y)** — Draws a right triangle from apex x,y to right x,y.

An example code snippet for the shape displays is in **Figure 9**.

Outputting a Waveform

Outputting a waveform is really a cool application for the Graphics library. The drawing shown here is “canned,” meaning it is not captured data but calculated data — just to illustrate the Graphics library drawing capability. Its function is:

- **plotsinx ()** — Calculates and plots an x times sin x function for display.

See **Figure 10** for an example code snippet.

Running the Demo Application

Hook up the Experimenter and display as shown in **Figure 11**. Download the complete Microchip project and source code from the *Nuts & Volts* website. As mentioned in previous articles, use Microchip’s Free IDE and PIC24F compiler to compile and then program the Experimenter using the PICkit 2 programmer.

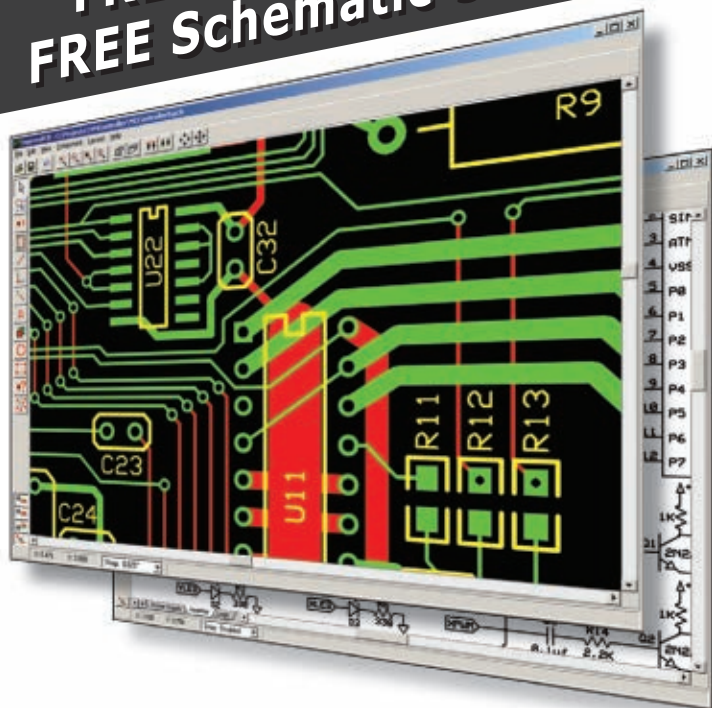
The Graphics demo application initializes the display and runs through a series of library features using a number of separate screens. Between each screen is a slight delay to allow easy viewing before switching to the next one. The MAIN code repeats itself as a continuous loop.

Display Incoming Data in Real Time

How about displaying real time data as it is coming in to one of the Experimenter’s ADC input channels? The Graphics library has a function that supports this, as well.

- **plotsignal (data array, number of data samples, x offset, y offset)** — This function takes an array of data samples and plots them in VMAP. The

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x and y offset centers or positions the plot on the display as needed.

In order to use this function, an incoming source of data samples is needed. This is where the ADC comes in. Recall from earlier articles, the Experimenter has an ADC library that allows any of several inputs on the expansion I/O to be configured as an ADC input channel. Once a channel is configured, you simply supply an incoming signal. I used my bench sine wave generator. Remember that the incoming signal must be between +3.3V and 0V, and should be centered at +1.5 volts if it varies in the negative as well as positive direction. With the channel configured and the signal source connected, begin collecting samples into the array. Once the array is filled, call the `plotsignal()` library function. To help things along,

another demo is provided called **SNAPSHOT**. The demo runs a continuous snapshot refreshing the display with what is captured from the ADC every couple of seconds. A picture of the demo is shown in **Figure 12** where a 3 kHz waveform is being digitized using pin 9 of the I/O expansion bus.

Now, we have a pretty cool graphics display system and a waveform snapshot viewer. There are a lot of potential experiments to perform to customize these library tools for applications. (A kit is available through the website with all the necessary graphics hardware and assembly instructions to get started.) Once the graphics display is connected, start out by modifying the Graphics demo. I hope you enjoy every bit of this new feature to add to your Experimenter. **NV**

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Experiments with Alternative Energy

Part 9 - Experimenting with the WindPitch Wind Turbine

By John Gavlik, WA6ZOK

In order to get the best results from the experiments in this series, a one-time purchase of the REEL Power software is necessary. It is available through the *Nuts & Volts* webstore at <http://store.nutsvolts.com>. There is a discount for NV subscribers. All downloads that complement these articles are available in the Media Downloads section of *Nuts & Volts* (www.nutsvolts.com) or on the LearnOnline website (www.learnonline.com).

Last month, I introduced the WindPitch horizontal axis wind turbine (HAWT) and described its principles of operation, as well as how this small device so closely emulates the large commercial wind turbines that dot the countryside. This time, I'll demonstrate some interesting experiments that can be done with it using the BS2 and 28X2 micros as data acquisition and measurement tools. Here are the topics we'll address:

- Blade Types
- Blade Pitch
- Number of Blades
- Measuring Power and Efficiency

To recap, the WindPitch is a HAWT with a three-phase AC alternator that is driven by curved blades that are designed to aircraft standards (**Figure 1**). The blades can be manually adjusted for pitch, and the removable hub can accommodate up to 12 blades (**Figure 2**). The whole thing stands about 18 inches tall from base to blade tip, and makes for some great wind experiments. What we're after is to determine which blade type, pitch, and number of blade combinations do the best in

Figure 1. The WindPitch HAWT.



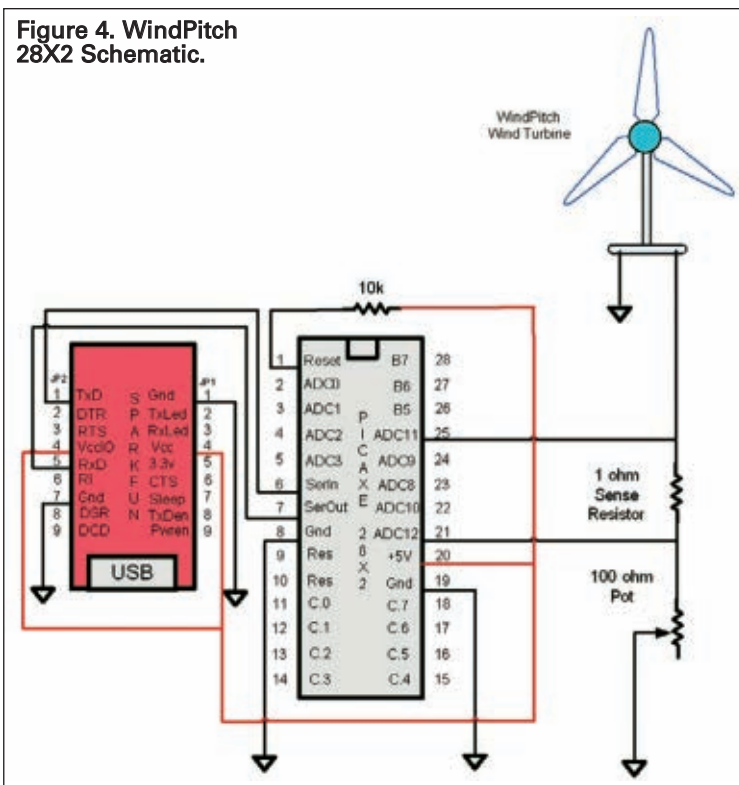
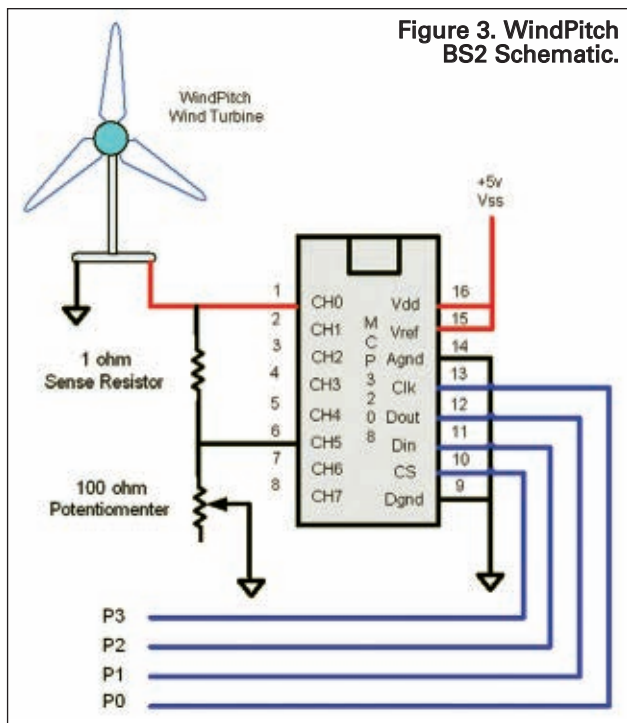
various wind conditions. This is summed up as an efficiency number that can be used across all the experiments. Let's get started, but first, review the recommended Safety Warnings (see **sidebar**).

Safety Warnings

Before you proceed with any of the experiments with the WindPitch, please note that the rotor blades can spin very fast under high wind, which makes it a likely candidate for injury if any part of your body encounters them. The use of protective eye goggles is highly recommended. You should also install the turbine properly so that it does not "walk" or topple over. The weight of the base along with the extended struts should prevent this from happening, but placing the turbine on a rubber mat or blanket as we did helps considerably.

Figure 2. Blade Pitch Adjustment Mechanism.





Micro Setups

To prepare for the experiments, you will need to configure your BS2 or 28X2 processors as shown in the schematics in **Figures 3 and 4**, respectively. You will also need to download the BASIC code firmware. This firmware outputs data to the REEL Power software that displays the voltage, current, power, and load resistance on your computer. Besides the schematics, you can find the micro component hookups, as well.

The WindPitch outputs rectified DC that is created by the three-phase alternator configured in a permanent STAR arrangement along with six diodes wired as a full-wave rectifier for the three phases. Parts 7 and 8 described how this works to rectify AC to DC so I won't repeat it here. Since there is no direct access to the three-phase AC outputs from the alternator, we will not be able to tap into them for any

experiments.

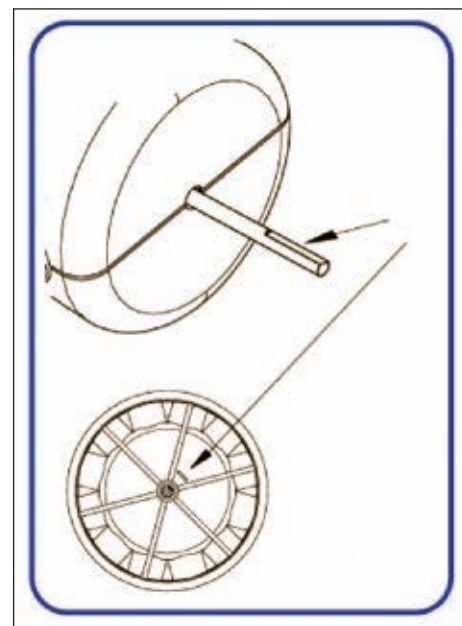
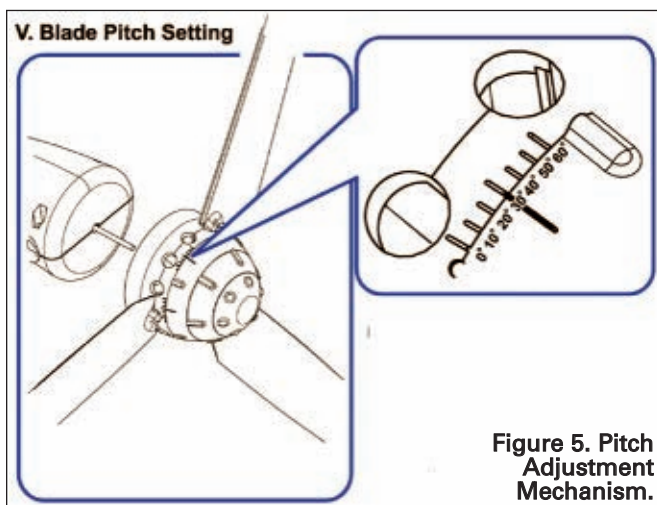
The end result is a rectified DC output that has a lot of ripple riding on it, which the BS2 and 28X2 code then “filters” so that the voltage data to the computer is steadier, and can thus produce more consistent current and power readings.

WindPitch Setup

We'll begin the experiments with three blades attached to the hub. I've chosen to start with the BP-28 type that comes with the WindPitch; there are two other blade types that we'll

also experiment with shortly. Once the three BP-28 blades are installed, set the pitch angle to about 10 to 15 degrees as shown on the hub pointer (**Figure 5**). If you haven't already done so, attach the hub to the metal alternator shaft. (Attaching the hub is about the only negative feature I've discovered in the WindPitch design.) To do this successfully, you'll need to

Figure 6. Hub Assembly Notch.



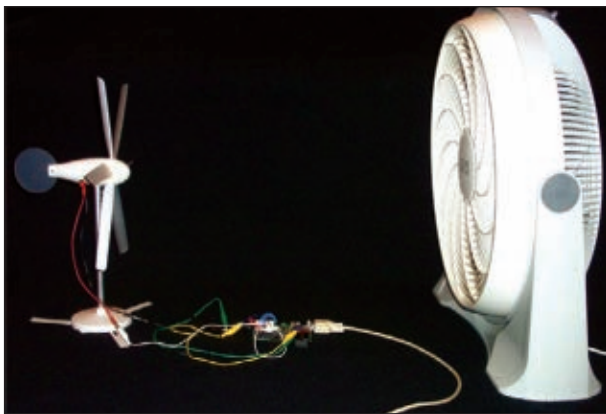


Figure 7. WindPitch/Fan Setup with BS2 Board of Education.

as well, so don't skimp here. Also, set the WindPitch about two feet away from the fan and not directly in front of it, since the wind will be more laminar (smoother) at this distance (Figure 7).

Finally, turn the fan on to its highest speed

carefully align the small "dash" mark on the inside of the hub with the flat part of the alternator shaft (Figure 6). Push the hub onto the shaft until it is nearly flush with the fuselage. If you don't properly align the dash mark and flat part of the shaft, it won't fit together.

The next thing to do is set the whole assembly in front of a large table or floor fan — preferably one that is about 16 inches in diameter or larger. The diameter of the fan blades should be at least 50 percent larger than the overall WindPitch blade diameter to deliver adequate wind; a smaller electric fan will work but not

setting and witness the turbine blades spinning. If the turbine is oscillating (yawing) wildly (which it can do in high winds produced by fans), you might want to adjust the set screw on the mounting pole to keep it steady (Figure 8).

For the following experiments, keep the distance between the fan and wind turbine the same — don't change it or else your data will be invalid.

With the WindPitch output wires connected to your microprocessor setup and your computer running the REEL Power software, adjust the 100 ohm [load] potentiometer to full resistance. You should witness a plot like Figure 9 where you can see voltage, current, and power

displayed. Even though the REEL Power software says Solar Panel Interface, this software will do fine for the WindPitch experiments since they are all DC and don't involve any three-phase AC like the Whirlybird™.

When you have all of this working, you're ready to start experimenting with this neat product.

Adjusting for Maximum Power Point

In order to form a baseline for the performance of the WindPitch for all conditions of blade types, blade pitch, wind speed, and so forth, we first want to know how to determine the Maximum Power Point (MPP). This is to create an even testing environment for all conditions. Recall from Part 1 that the MPP is achieved when the impedance of the power source equals the impedance of the load. This is done by adjusting the 100 ohm load resistance pot to match the impedance of the three-phase alternator. From previous experimenting, I have already determined that the average impedance of the WindPitch three-phase alternator [after being full-wave rectified] is between 50 and 75

Figure 8. Fuselage Set Screw.

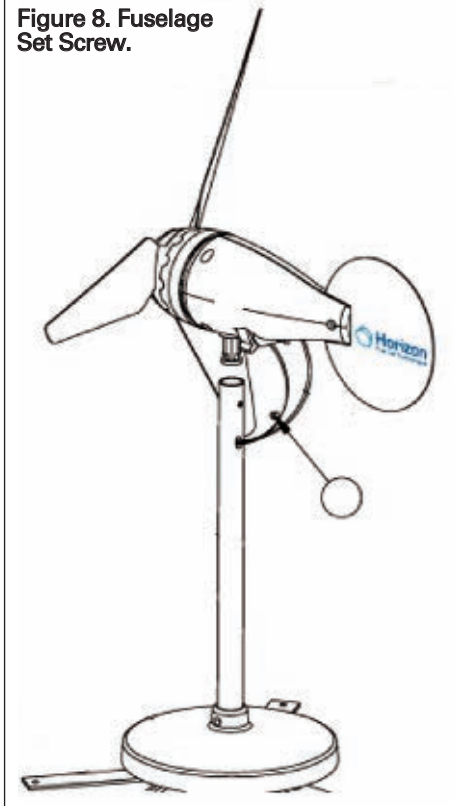
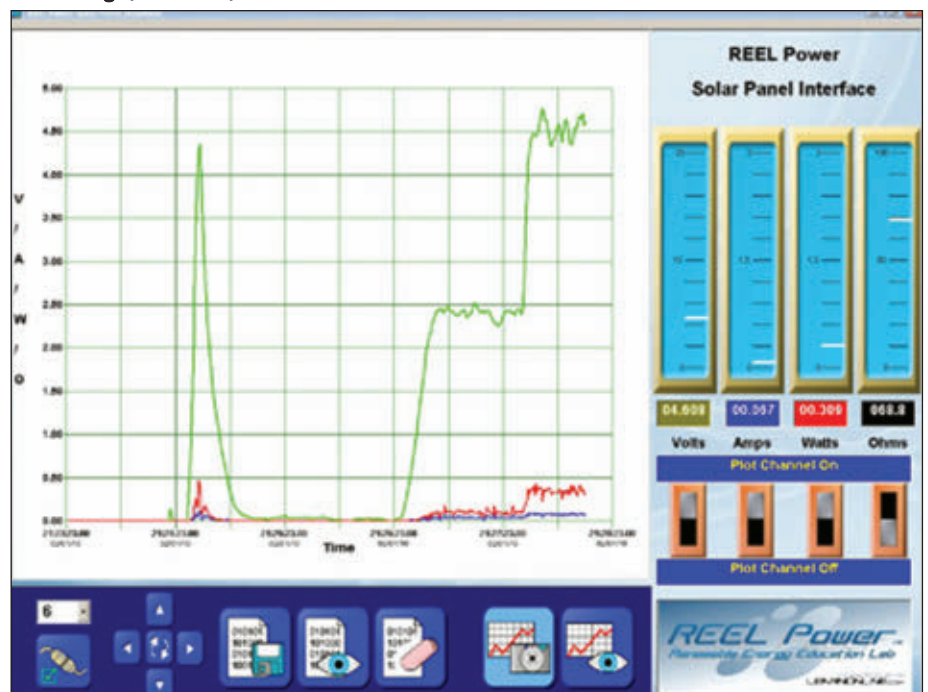


Figure 9. Typical REEL Power view of Voltage, Current, and Power.



ohms. This is where you will usually find the maximum power being delivered into the potentiometer load. However, this exact value varies depending on the wind speed, blade type, and number of blades and blade pitch, and it will need adjusting. So, with the fan on and wind blowing across the WindPitch blades, adjust the pot until maximum power is displayed on the computer plot. This adjustment is what you will do for each one of the remaining experiments.

Measuring Wind Speed

An important part of these experiments is measuring wind speed, but before you can begin to compare power and efficiency readings you will need to acquire a handheld anemometer to measure wind speed. There are many out there and the one I've selected to do these experiments with is the La Crosse model shown in **Figure 10**. I like it because it can be set to measure wind speed in meters per second, which is what the Wind Power Equation we'll cover below requires. (I introduced the La Cross anemometer and the Wind Power Equation to you in Part 7 for the Whirlybird wind turbine.)

In order to measure the fan's wind speed, place the anemometer directly in front of the turbine's blades at three places: left, middle,

and right. Take the average of the three readings for the measurement. However, be sure to do this either before or after measuring the power as the anemometer and your hand will interfere with the wind against the blades and may produce inaccurate results.

Recall the Wind Power Equation:

$$P = 0.5 \cdot \rho \cdot A \cdot V^3 \cdot E$$

where:

P = Power in watts

ρ = Air Density in Kg/m³ (about 1.225 Kg/m³ at sea level; less higher up)

A = Rotor Swept Area in m² = πr^2 (r = radius or blade length)

V = Wind Speed in m/s (cubed)

E = Efficiency in percent

As you discovered in Part 7, it's the turbine's efficiency (E) that's the wild card in this equation, so let's reconfigure it to measure efficiency directly. This will tell us how each combination of blade type, blade pitch, and number of blades affects the overall turbine performance. We'll get the electrical power (P) directly from the computer display.

$$E = P / 0.5 \cdot \rho \cdot A \cdot V^3$$

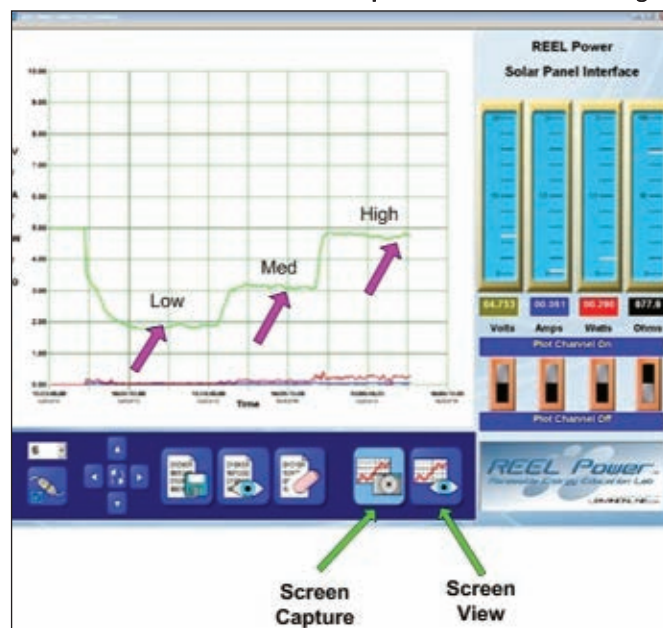
One of the variables that you will need to determine is the air density (ρ) at your altitude and temperature. The sidebar



Figure 10. La Cross Anemometer.

illustrates a calculator that I used that works well except you'll have to convert from English units (lbs/ft³) to metric units (Kg/m³). (I'm sure there's a calculator for that on the web, too.) Also, I can tell you that the Rotor Swept Area (A) for all the blade types = 0.099 m². Again, the goal is to determine the overall efficiencies (E)

Figure 11. Using REEL Power Software to Capture Stabilized Readings.



Air Density Calculator

Here's a website to compute air density at your altitude and temperature: www.denysschen.com/catalogue/density.asp.



Blade Type/Angle ®	BP-28 (150)	NACA-44 (150)	NACA-63 (150)
Wind Speed	3 blades	3 blades	3 blades
Low (1.4 m/s)	P = 0.049 watts	P = 0 watts	P = 0 watts
Low (1.4 m/s)	E = 0.900	E = 0	E = 0
Medium (2.2 m/s)	P = 0.21 watts	P = 0.113 watts	P = 0.133 watts
Medium (2.2 m/s)	E = 0.568	E = 0.535	E = 0.629
High (4.6 m/s)	P = 0.336 watts	P = 0.309 watts	P = 0.307 watts
High (4.6 m/s)	E = 0.174	E = 0.160	E = 0.159

Table 1. Comparison of Three Blade Types to Three Wind Speeds.

Blade Type/Angle ®	BP-28 (150)	NACA-44 (150)	NACA-63 (150)
Wind Speed	6 blades	6 blades	6 blades
Low (1.4 m/s)	P = 0.059 watts	P = 0.011 watts	P = 0.050 watts
Low (1.4 m/s)	E = 1.080	E = 0.202	E = 0.918
Medium (2.2 m/s)	P = 0.154 watts	P = 0.363 watts	P = 0.102 watts
Medium (2.2 m/s)	E = 0.729	E = 1.718	E = 0.483
High (4.6 m/s)	P = 0.320 watts	P = 0.327 watts	P = 0.290 watts
High (4.6 m/s)	E = 0.166	E = 0.169	E = 0.150

Table 3. Comparison of Three Blade Types with Six Blades.

Condition	Highest	Lowest
3 Blades at 150	BP-28	NACA-63
3 Blades at 150, 300 and 450	BP-28	NACA-63
6 Blades at 150	NACA-44	NACA-63

Table 4. Overall Comparison of Efficiency Readings.

Blade Type/Angle ®	BP-28 (150)	BP-28 (300)	BP-28 (450)
Wind Speed	3 blades	3 blades	3 blades
Low (1.4 m/s)	P = 0.049 watts	P = 0.034 watts	P = 0.012 watts
Low (1.4 m/s)	E = 0.900	E = 0.624	E = 0.220
Medium (2.2 m/s)	P = 0.012 watts	P = 0.080 watts	P = 0.230 watts
Medium (2.2 m/s)	E = 0.568	E = 0.379	E = 1.088
High (4.6 m/s)	P = 0.336 watts	P = 0.190 watts	P = 0.115 watts
High (4.6 m/s)	E = 0.174	E = 0.098	E = 0.059
Blade Type/Angle ®	NACA-44 (150)	NACA-44 (300)	NACA-44 (550)
Wind Speed	3 blades	3 blades	3 blades
Low (1.4 m/s)	P = 0 watts	P = 0.008 watts	P = 0.003 watts
Low (1.4 m/s)	E = 0	E = 0.147	E = 0.055
Medium (2.2 m/s)	P = 0.113 watts	P = 0.046 watts	P = 0.019 watts
Medium (2.2 m/s)	E = 0.535	E = 0.218	E = 0.089
High (4.6 m/s)	P = 0.309 watts	P = 0.131 watts	P = 0.048 watts
High (4.6 m/s)	E = 0.160	E = 0.068	E = 0.025
Blade Type/Angle ®	NACA-63 (150)	NACA-63 (300)	NACA-63 (450)
Wind Speed	3 blades	3 blades	3 blades
Low (1.4 m/s)	P = 0 watts	P = 0.010 watts	P = 0.009 watts
Low (1.4 m/s)	E = 0	E = 0.164	E = 0.165
Medium (2.2 m/s)	P = 0.133 watts	P = 0.032 watts	P = 0.015 watts
Medium (2.2 m/s)	E = 0.629	E = 0.151	E = 0.071
High (4.6 m/s)	P = 0.307 watts	P = 0.116 watts	P = 0.039 watts
High (4.6 m/s)	E = 0.159	E = 0.060	E = 0.020

Table 2. Comparison of Three Blade Types to Three Pitch Angles.

for the three blade types, pitch angles, and number of blades.

Measurement Shortcut

The electrical data from the WindPitch is not very stable due to the excessive ripple riding on the DC output. Therefore, to help capture the voltage and power data that's needed for the experiments, I recommend that you use the Screen Capture and Screen View capabilities that are built into the REEL Power software. This way, you can capture a snapshot of the measurement as the data changes. Simply allow the

WindPitch to spin up to speed at each of the three fan settings, then click the Screen Capture icon to capture the data on the screen. Next, click on the Screen View icon to read the captured data. **Figure 11** is one example of allowing the data to stabilize and then capturing it.

Blade Types

To begin the WindPitch experiments, I've first chosen to compare the three blade types (BP-28, NACA-44, and NACA-63) using three blades at the same pitch angle. We want to measure the blade

performance at a 15 degree pitch angle at three fan speed settings: low, medium, and high. With the turbine blades spinning, record the power along with the wind speed. Then, plug the numbers into the Power Equation to determine efficiency.

We really don't need the voltage for our efficiency comparisons, but it helps to see what's happening as the turbine spins. Remember, for each fan speed and power reading you want to adjust the 100 ohm pot for maximum power at that wind speed setting. **Table 1** is what I recorded.

At first glance, it is interesting to note the overall low power and

equally low efficiency readings given at what appears to be a lot of wind power going into the device, along with the fast spinning blades at high wind speeds. That's about all this small device can deliver with a relatively heavy load of about 50 to 75 ohms. What's equally interesting are the efficiency readings — the highest of which is at the lowest wind speed, and the lowest at the highest wind speed (not including zero power because the blades could not spin at the low wind speeds). So, just because we're producing more power at higher wind speeds doesn't mean that our wind turbine is any more efficient at this setting. So, let's see what else blade pitch and number of blades can do for these readings.

Blade Pitch

Repeat the same experiment with the three blade types at three

different blade pitch settings as shown in **Table 2**. Recall that setting the blade pitch involves three parts of the hub assembly (the Blade Pitch Controller, Blade Assembly Lock, and Rotor Assembly Lock) that are screwed onto the Rotor Base forming a completed assembly (again as shown in **Figure 2**). By partially unscrewing the Rotor Assembly Lock, you can adjust the blade pitch and then lock it in place again. Remember, each pitch mark represents 10 degrees of angle. **Table 2** shows my results.

Number of Blades

Finally, we want to do the same experiment with six blades. The WindPitch normally doesn't come with more than three blades of the same type, but I've got the requisite number for these tests, so you can queue off my results. You can also purchase more if you like. For these tests, I set the blade pitch at 15

degrees. The results are in **Table 3**.

Comparing Efficiencies

With the data taken for all the variables of blade type, blade pitch, and number of blades and wind speed, we now come to comparing what combinations did best (**Table 4**). As the data clearly indicates, the BP-28 blade is the most efficient in two out of three trials, while the NACA-63 comes in last in each category of testing. Also, it appears that six blades had the largest efficiency.

With that said, let's not jump to conclusions since these comparisons represent the extreme end points of our measurements. Each case must be judged based on its individual wind speed, pitch angle, and blade type, and number conditions. A general point, however, is that in low wind a higher pitch angle is best while in high wind, a lower pitch

Blade Comparison Chart
2/1/2010

BP-28	Wind Speed		Number of Blades / Pitch Angle								
			2B / 15	2B / 30	2B / 45	3B / 15	3B / 30	3B / 45	6B / 15	6B / 30	6B / 45
	1.4m/s	Volts	0	0.616	0.472	1.3	1.14	0.71	1.7	1.12	0.821
	1.4m/s	Watts	0	0.005	0.011	0.049	0.034	0.012	0.059	0.026	0.017
	1.4m/s	Eff	0	0.092	0.202	0.9	0.624	0.22	1.08	0.478	0.312
	2.2m/s	Volts	2.13	1.31	0.948	2.4	1.9	1.17	2.6	1.84	1.26
	2.2m/s	Watts	0.083	0.035	0.02	0.12	0.08	0.23	0.154	0.132	0.035
	2.2m/s	Eff	0.393	0.166	0.01	0.568	0.379	1.088	0.729	0.625	0.166
	4.6m/s	Volts	4.58	2.38	1.79	4.2	3.02	1.95	4.05	2.87	2.03
	4.6m/s	Watts	0.325	0.15	0.045	0.336	0.19	0.115	0.32	0.141	0.099
	4.6m/s	Eff	0.168	0.078	0.233	0.174	0.098	0.059	0.166	0.073	0.051

NACA 44	Wind Speed		Number of Blades / Pitch Angle								
			2B / 15	2B / 30	2B / 45	3B / 15	3B / 30	3B / 45	6B / 15	6B / 30	6B / 45
	1.4m/s	Volts	0	0.279	0.365	0.04	0.743	0.621	1.84	0.098	0.654
	1.4m/s	Watts	0	0.001	0.003	0	0.008	0.003	0.011	0.01	0.006
	1.4m/s	Eff	0	0.184	0.055	0	0.147	0.055	0.202	0.184	0.11
	2.2m/s	Volts	0	1.005	0.77	2.461	1.642	1.1	2.9	1.34	1.05
	2.2m/s	Watts	0	0.013	0.011	0.113	0.046	0.019	0.363	0.32	0.016
	2.2m/s	Eff	0	0.062	0.052	0.535	0.218	0.089	1.718	1.51	0.076
	4.6m/s	Volts	4.33	2.308	1.568	4.61	2.67	1.775	4.42	2.22	1.745
	4.6m/s	Watts	0.247	0.087	0.036	0.309	0.131	0.048	0.327	0.55	0.038
	4.6m/s	Eff	0.128	0.045	0.019	0.16	0.068	0.025	0.169	0.285	0.0196

NACA 63		Number of Blades / Pitch Angle									
		Wind Speed	2B / 15	2B / 30	2B / 45	3B / 15	3B / 30	3B / 45	6B / 15	6B /30	6B / 45
	1.4m/s	Volts	0	0.286	0.32	0.063	0.822	0.628	1.84	1.157	0.849
	1.4m/s	Watts	0	0.001	0.001	0	0.01	0.009	0.05	0.014	0.011
	1.4m/s	Eff		0.018	0.018	0	0.184	0.165	0.918	0.257	0.202
	2.2m/s	Volts	0	0.977	1.002	2.459	1.546	1.067	3.09	1.857	1.374
	2.2m/s	Watts	0	0.012	0.002	0.133	0.032	0.015	0.102	0.05	0.022
	2.2m/s	Eff		0.057	0.009	0.629	0.151	0.071	0.483	0.237	0.104
	4.6m/s	Volts	3.96	2.386	1.703	4.257	2.626	1.712	4.753	2.905	2.082
	4.6m/s	Watts	0.162	0.079	0.041	0.307	0.116	0.039	0.29	0.113	0.096
	4.6m/s	Eff		0.041	0.021	0.159	0.06	0.02	0.15	0.059	0.05
	wind speed	power	E								
	1.4	0.011	0.20200284								
	2.2	0.022	0.104112658								
	4.6	0.096	0.049698884								

angle works better. This is consistent with how the gear ratios work in a car's transmission — more grappling force is required at startup, while much less is required at cruising speeds.

A commercial wind turbine works the same way by widening the pitch angle at lower wind speeds and narrowing it at higher wind speeds. So, while our WindPitch doesn't put out a lot of power, it does conform to these general operational principles.

RPM

I intended to also measure rpm for these experiments, but the

WindPitch rotational speeds are too high for the BS2 and 28X2 BASIC interpreter's clock speed to capture. In effect, the BASIC code can't keep up with rotational time periods, and I didn't want to get into assembly language programming to see if it could be done with that. If you've done any coding in assembly, you know that it's the fastest way to make a micro run through any firmware algorithm. What is not so well understood is that coding in assembly and having it "called" using a BASIC interpreter may not always be as fast as one would expect (given the fact that the BS2 and 28X2 need to toggle between their BASIC interpreter and the assembly code).

This is the fundamental reason why I skipped it.

What I can say, however, is that the WindPitch spins about five times faster than the Whirlybird due mainly to its smaller physical size and smaller alternator. I've run the WindPitch up to 1,700 rpm (measured with another device) and I know it can spin faster with higher fan wind speeds.

Summary

Even though the WindPitch is not the most powerful wind turbine out there, it IS the best one I have come across for desktop experimenting. It teaches all the main principles of HAWT technology in a compact, comprehensive unit, so I highly recommend it.

In closing for now, I hope that you have enjoyed these four articles on wind power. Next time, I'm starting a new series of alternative energy articles on hydrogen and hydrogen fuel cells — those devices that promise to power our cars and homes in the near future (as long as we can find some viable sources for hydrogen in the process).

To help achieve that goal, we'll use solar and wind power to generate hydrogen using a device called an electrolyzer that splits water into hydrogen and oxygen. I think you'll find this new alternative energy series interesting and engaging. So, until next time, conserve energy and stay green. **NV**





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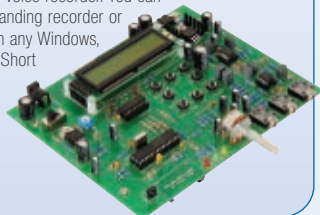
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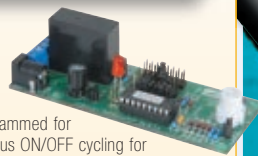
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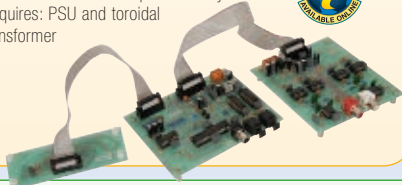


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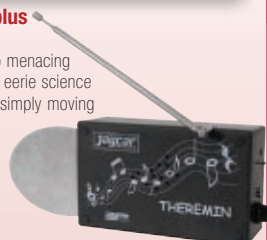
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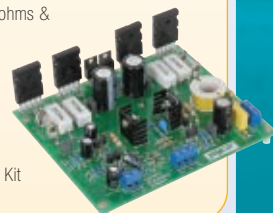
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Program **Small** Devices With **Big** Abilities

Recently, I discovered a new way to program small devices while using the same programming language, integrated development environment (IDE), and debugger I use for PC applications. The key is the .NET Micro Framework — a special edition of .NET for devices that don't have the resources to run Windows. You write code in Visual C#, and develop and debug using the Visual Studio IDE.

By Jan Axelson

Small devices need I/O, and the .NET Micro Framework supports plenty of it, including basic input and output ports, serial interfaces, networking, USB device functions, and displays — even touch screens. Vendor classes add support for USB host functions and more.

The .NET Micro Framework has expanded my ideas about the kinds of small devices I can create without a big investment in tools and time. This article will show how you can use the .NET Micro Framework in your projects.

A .NET Edition for Devices

Microsoft's .NET Framework has long been a popular platform for writing applications for PCs. You can program .NET applications in Visual Basic, Visual C#, and other visual languages. (Microsoft only supports Visual C# on the .NET Micro Framework. For more about the language, see the sidebar *About Visual C#*.)

The Framework includes class libraries to support common tasks. For example, the `SerialPort` class provides properties, methods, and events for communicating with RS-232 and similar serial ports.

The Framework also provides a common language runtime (CLR) which manages program execution. The CLR frees applications from the low-level details of managing memory, threading, exceptions, garbage collection, and security. Visual Studio provides an IDE and debugger for programming in .NET languages.

Small devices that run Windows Embedded can use the .NET Compact Framework. However, the .NET Micro Framework goes a step further and provides a way to run .NET programs on devices that don't use Windows at all. If you have experience with .NET programming on PCs, much about the .NET Micro Framework will be familiar.

Multiple vendors offer modules with support for the .NET Micro Framework built in. A porting kit from Microsoft supports several processors. Most of the modules available from vendors use 32-bit ARM7 or ARM9 CPUs which have the resources to support running .NET Micro Framework programs.

GHI Electronics has a wide selection of modules. The FEZ Mini (**Figure 1**) has basic interfaces for simpler projects (and its own website at tinyclr.com). On the other end of the spectrum, the ChipworkX board supports just about any type of I/O you might want, including a touch panel and USB host and device functions.

Figure 2 shows a touch-screen data logger I designed on the ChipworkX board. The screen shows images of target bird species. When you touch an image, the logger reads time and location information from a GPS unit and stores the bird type and GPS data on a Flash drive.

That's just one example of what you can do with the .NET Micro Framework. For links to this and many other projects, see microframeworkprojects.com.

Getting Started

The first step in using the .NET Micro Framework is installing its software development kit (SDK) and Visual C# Express. Both are free downloads. If you have a paid edition of Visual Studio, you can use it instead of the Express edition. While you're developing a project, you can run your application on the provided software emulator (**Figure 3**) or deploy the application to your hardware. GHI Electronics has a free guide to writing and running programs on the emulator and device hardware.

The documentation included with the SDK is a little short on explanations and examples of the classes that are specific to the .NET Micro Framework. To fill in the gaps, I found the book *Expert .NET Micro Framework, Second Edition* by Jens Kuhnert (APress) helpful. If you want to dig deep, Microsoft has released most of the source code for the .NET Micro Framework as open source. (It's in the porting kit.)

Classes for I/O

Small devices often need direct access to port bits, and the .NET Micro Framework adds

classes for this purpose. The `OutputPort` class defines read/write port bits. The `InputPort` class supports reading only. On the ChipworkX board, pin PC5 controls an LED. This constructor defines the output port `Led1` on PC5 with an initial state of true (logic high).

```
internal static OutputPort Led1 =
    new OutputPort(Processor.Pins.PC5, true);
```

To set the bit low and turn off the LED, use:

```
Led1.Write(false);
```

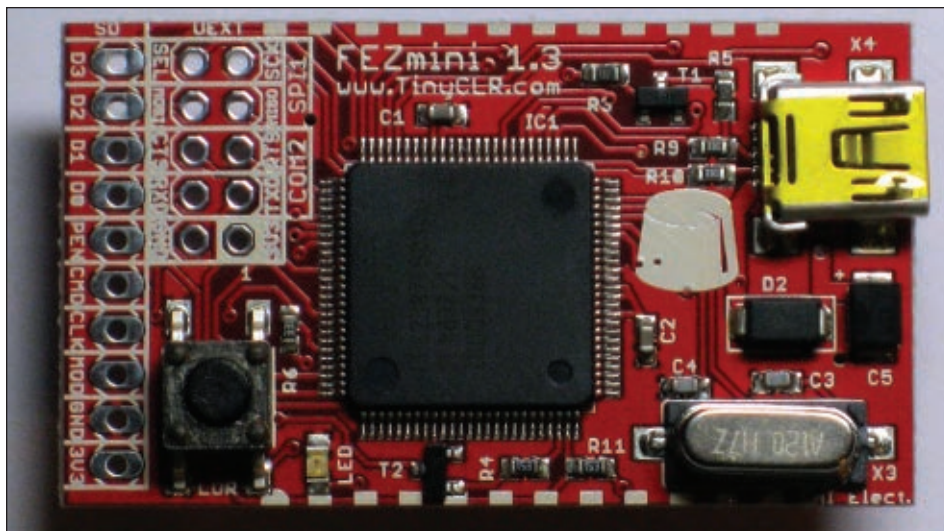
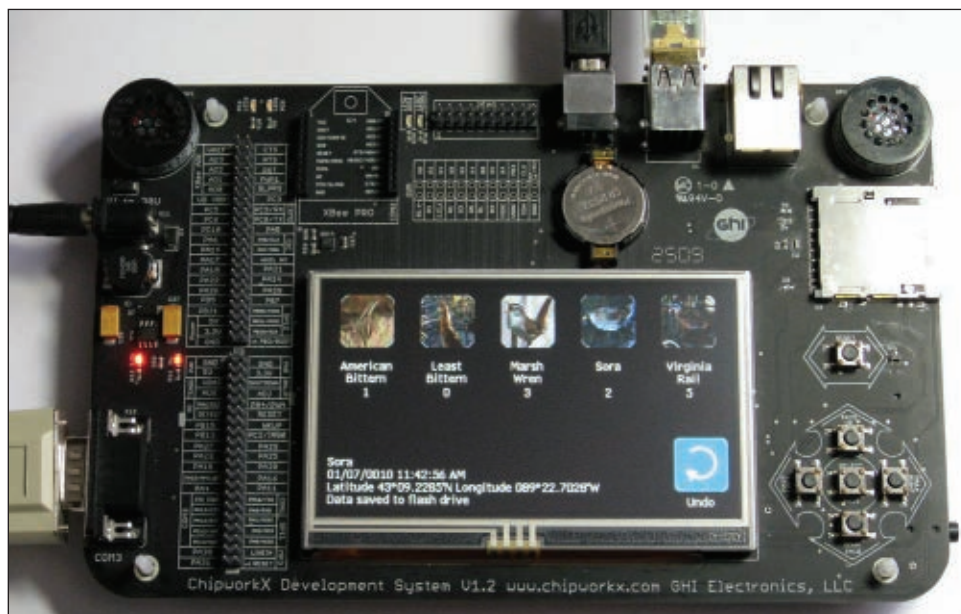


FIGURE 1. The FEZ Mini has analog and digital I/O, a UART port, and two 12-pin headers for inserting into a printed circuit board or breadboard.

FIGURE 2. This ChipworkX board is hosting a touch-screen data logger that reads GPS data and stores it in a Flash drive.



Resources

FEZ Modules
www.tinyclr.com

GHI Electronics
www.ghielectronics.com

Microsoft .NET Micro Framework Page
www.microsoft.com/netmf

.NET Micro Framework Projects
www.microframeworkprojects.com

Visual C# Developer Center
msdn.microsoft.com/en-us/vcsharp

Visual C# Express
www.microsoft.com/express/Windows

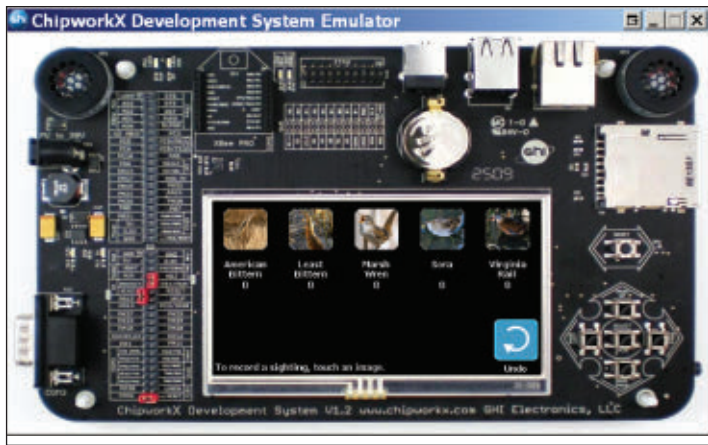


FIGURE 3. The provided software emulator includes a “live” image of the development board as it runs your .NET Micro Framework code.

To set the bit high and turn the LED on, use:

```
Led1.Write(true);
```

The `InterruptPort` class supports events that can respond to a user action or other event at a port bit. On the ChipworkX board, pin PA23 connects to a pushbutton. This constructor defines an `InterruptPort` object on the pin:

```
InterruptPort port = new InterruptPort(
    Processor.Pins.PA23,
    true,
    Port.ResistorMode.PullUp,
    Port.InterruptMode.InterruptEdgeHigh);
```

Setting the second parameter as `true` enables a glitch filter that ignores switch bounce on mechanical switches. The `ResistorMode` parameter can set a chip’s internal resistor — if available — to pull-up, pull-down, or no resistor. The `InterruptMode` parameter specifies whether to trigger an event on a rising edge, falling edge, both, or a high or low level.

The `OnInterrupt` method assigns a routine to execute when an interrupt event occurs:

```
port.OnInterrupt +=
    new NativeEventHandler(port_OnInterrupt);
```

The parameters passed to the `port_OnInterrupt` routine identify the port and port state, and provide a `TimeSpan` value that indicates when the event occurred. The routine below responds to a switch press by toggling `Led1`. The routine reads the state of `Led1` and writes the opposite state back to the bit. A `Debug` statement displays the values of the passed parameters in Visual Studio’s Output window:

```
private static void port_OnInterrupt(
    uint port, uint state, TimeSpan time)
{
    Led1.Write(!(Led1.Read()));
    Debug.Print("Pin " + port +
        " State= " + state +
        " Time= " + time);
}
```

On pressing button PA23, the LED’s state toggles and the Output window displays the values of the parameters:

```
Pin 23 State= 1 Time= 00:00:42.2742919
```

Accessing Serial Ports

To access RS-232 ports, you can use a `SerialPort` class that is similar to the `SerialPort` class in the full .NET Framework. This example creates a `SerialPort` object, sets parameters for communicating with a GPS unit, and opens the port:

```
private SerialPort comPort = new SerialPort(
    "COM3", 4800, Parity.None, 8, StopBits.One);
comPort.Handshake = Handshake.None;
comPort.Open();
```

The constructor sets the port name (COM3) to match the name assigned to the RS-232 port on the ChipworkX board. The port communicates at 4800 bits/sec with no parity, eight data bits, and one Stop bit. The `Handshake` property specifies the type of handshaking (flow control) — if any — for the port.

After calling the `Open` method, the application can read data from the port:

```
Byte[] receivedDataBuffer =
    new Byte[comPort.BytesToRead];
comPort.Read(
    receivedDataBuffer,
    0,
    receivedDataBuffer.Length);
```

The `receivedDataBuffer` byte array holds the received data. The `BytesToRead` method returns the number of bytes waiting in the buffer. The `Read` method stores the received data in the buffer. The second parameter (0) is the beginning array index for storing the data, and `receivedDataBuffer.Length` is the number of bytes to read.

The .NET Micro Framework also provides classes for accessing components with SPI and I²C serial interfaces.

Adding a Flash Drive

To access USB peripherals, a device must have a USB host port and support for USB host functions. GHI Electronics provides hardware and software support for accessing a variety of USB peripherals from .NET Micro Framework applications.

Probably the most popular USB device for small systems is the Flash drive. Accessing a drive requires three steps: detecting and initializing the drive; getting directory and file information; and reading and writing to files.

Jan Axelson is the author of *USB Complete* and *Serial Port Complete*. Her website is www.Lvr.com.

The built-in support from the .NET Micro Framework and GHI greatly simplifies the code you need to provide. Detecting and initializing a drive requires jumping through a few programming hoops, but the same boilerplate code can do the job for any application. Example code will get you going quickly.

The .NET Micro Framework's RemovableMedia class provides events for detecting insertion and removal of SD cards and similar storage media. The class's Insert and Eject events can define handlers that execute on detecting a newly attached or removed RemovableMedia device:

```
RemovableMedia.Insert +=
    new InsertEventHandler(RemovableMediaInsert);
RemovableMedia.Eject +=
    new EjectEventHandler(RemovableMediaEject);
```

GHI's SystemManager and PersistentStorage classes enable using these same events to detect attachment and removal of Flash drives. The SystemManager class has a Start method that registers a routine that executes when a Flash drive is attached or removed:

```
SystemManager.Start(SystemEvent);

void SystemEvent(
    SystemEventType type, SystemEventArgs args)
{
    if (type ==
```

```
SystemEventType.DevicesConnectionChanged &&
args.device.deviceType == DeviceType.Drive)
{
    if (args.isDeviceConnected)
    {
        // A drive has been attached.
        new PersistentStorage(
            args.device.deviceID).MountFileSystem();
    }
    else
    {
        // A drive has been removed.
        PersistentStorage[] storageList =
            PersistentStorage.GetPersistentStorageList();
        foreach (PersistentStorage
            myPersistentStorage in storageList)
        {
            if (myPersistentStorage.ID ==
                args.device.deviceID)
            {
                myPersistentStorage.UnmountFileSystem();
                myPersistentStorage.Remove();
                break;
            }
        }
    }
}
```

The parameters received by the SystemEvent routine identify the event type and provide a device ID.

On device attachment, the event routine can use the device ID to create a PersistentStorage object. The MountFileSystem method enables accessing the drive's

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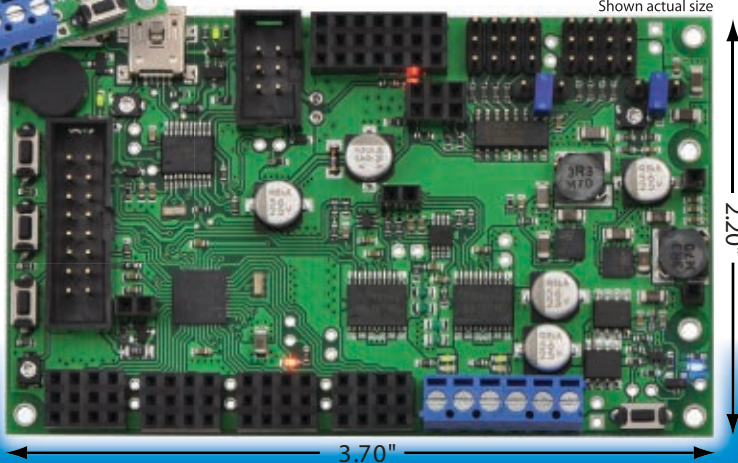
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directories and files. The new PersistentStorage object appears as a RemovableMedia device which causes the InsertEventHandler routine to execute.

The InsertEventHandler routine can access a MediaEventArgs parameter that holds information about the drive including whether the drive is formatted, the file system, volume name, root directory, size, and free space. To obtain the directories and files, the System.IO.Directory class provides the GetDirectories and GetFiles methods.

```
private String rootDirectory = "";
internal void RemovableMediaInsert(
    object sender, MediaEventArgs e)
{
    if (e.Volume.IsFormatted)
    {
        rootDirectory = e.Volume.RootDirectory;
        string[] dirs =
            Directory.GetDirectories(
                e.Volume.RootDirectory);
        string[] files =
            Directory.GetFiles(
                e.Volume.RootDirectory);
    }
    else
    {
        Debug.Print(
            "Media not formatted as FAT32.");
    }
}
```

After an application has detected a drive, reading and writing is similar to accessing drives in programs for PCs.

This example creates a new StreamWriter object for the file *mydata.txt* in the root directory. If the file doesn't exist, the constructor creates it. If the file does exist, the constructor's second parameter is set true to append data to the file or false to overwrite the existing file:

```
String filePath =
    rootDirectory + "\\\" + "mydata.txt";
String stringToWrite = "hello, world";

using (StreamWriter myStreamWriter =
    new StreamWriter(filePath, true))
{
    myStreamWriter.Write(stringToWrite);
    myStreamWriter.Close();
}
```

The *using* statement encloses the code that accesses the file and ensures that the Dispose method is called and the file's resources are released even if an exception occurs when accessing the file. The Write method appends a string to the file. When finished accessing the file, the close method closes the object and its stream.

On device removal, the SystemEvent routine unmounts the file system and removes the PersistentStorage object associated with the device ID. The RemovableMedia class's Eject event is raised, and the event's method can inform the application that the device is no longer available.

And Much More

I've covered just a few of the Micro Framework's abilities. One of my favorite features is the support for

touch screens (which offer user input and a display in one). You use Windows Presentation Foundation (WPF) classes to place images and text on a screen, respond to touches, and more. Whatever your next project requires, the .NET Micro Framework is worth a look. **NV**

About Visual C#

Visual C# is a programming language that has roots in C but is object oriented like Java. Many keywords, symbols, and structures are borrowed from C.

If you're a Visual Basic programmer, please don't despair. Over time, Visual Basic and Visual C# have grown much closer, and switching between languages is much less of a burden than it once was. Both languages support the .NET Framework's classes, and both can use Visual Studio's programming environment.

Here are variables declared in Visual Basic:

```
Dim horizontalSpacing As Int32 = 16
Dim statusMessage As String = "OK"
```

And here are the same variables declared in Visual C#:

```
Int32 horizontalSpacing = 16;
String statusMessage = "OK";
```

Each declaration contains the same information. The differences include word order, Visual Basic's added *Dim...As*, and Visual C#'s line-ending semicolons.

In general, Visual C# tends to prefer symbols for operations where Visual Basic uses words. Here are some logical operators in Visual Basic and Visual C#

Logical Operation	AND	OR	XOR	NOT
Visual Basic	And	Or	Xor	Not
Visual C#	&		^	!

Of course, there are fine points that may trip you up at first. For example, when declaring an array's size in Visual Basic, you specify the upper bound, while in Visual C#, you specify the number of elements. Here is a four-byte array in Visual Basic:

```
Dim buffer As Byte() = New Byte(3)
```

and here is the same array in Visual C#:

```
Byte[] buffer = new Byte[4];
```

The resulting arrays are identical and support indexes 0–3.

If you get stuck on how to do something in C#, code converters such as the one at **converter.telerik.com** do a pretty good job of converting code snippets from Visual Basic to Visual C#.

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#21
SMILEY'S

WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

Breadboarduino

by Joe Pardue

Follow along with this series!
Joe's book & kits are available in our
webstore at www.nutsvolts.com

Recap

Last month, we finished a three part series on serial communications between a PC and an Arduino. We used C# .NET Express to build an Arduino Voltmeter GUI, and we also learned a bit more about the FT232R USB to Serial Port IC that makes Arduino communication with a microcontroller so easy. We now have enough background that we can bust up the Arduino and reconstruct our own version from the pieces.

Why Bust Up A Perfectly Good System?

There are many folks who are ready to move beyond what Arduino does easily. This leads to attempts to twist the Arduino concept all out of shape to make it do things it just wasn't designed for. I'm seeing arguments developing on various Internet forums between Arduino novices and folks more experienced with microcontrollers who sometimes seem to be yelling at each other across a Grand Canyon sized gap in knowledge. The novice has found that the things the Arduino does well are easy to do, and they don't seem to understand that many of the things that the Arduino doesn't do easily can be quite difficult to learn. The experienced folks who probably haven't messed with the Arduino know that microcontrollers can be difficult to learn about, and don't

seem to understand why anyone would think otherwise. IMHO, the main thing that both sides are missing is that the intended audience for the Arduino was never expected to be or become an expert in microcontrollers.

Consider for a moment the intended audience for the Arduino as stated by Massimo Banzi in his book, *Getting Started with Arduino*:

"A few years ago, I was given the very interesting challenge: Teach designers the bare minimum in electronics so that they could build interactive prototypes of the objects they were designing."

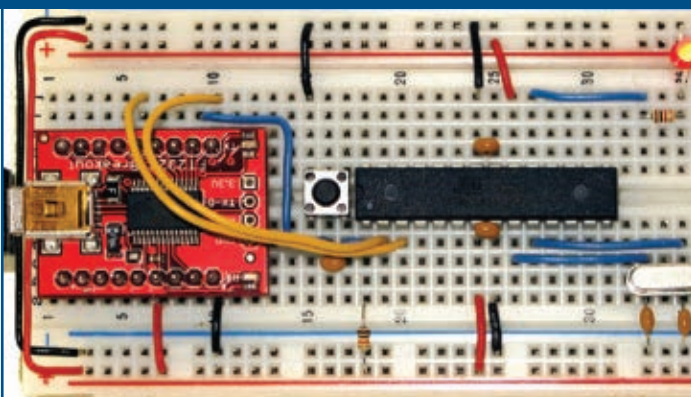
He summarizes his philosophy of 'learning by tinkering' with a quote from www.exploratorium.edu/tinkering:

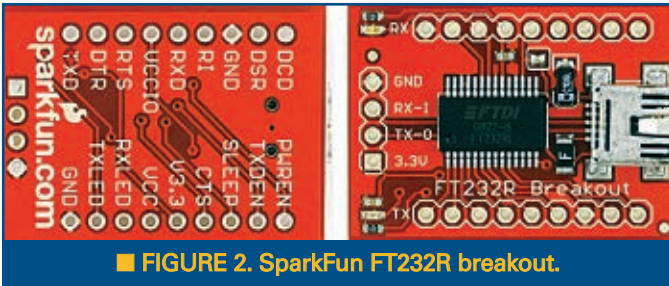
"Tinkering is what happens when you try something you don't quite know how to do, guided by whim, imagination, and curiosity. When you tinker, there are no instructions – but there are also no failures, no right or wrong ways of doing things."

That last sentence is both the most fun and the most difficult to get beyond. Creativity requires this sort of playfulness, but my experience with microcontrollers – moving beyond what the Arduino does easily – involves about 90% of my time correcting failures. My work habit is to literally fail my way to success. Sorry, but if you want to move beyond being a novice, you have to forget that last sentence – *"but there are also no failures, no right or wrong ways of doing things"* – because there really are right and wrong ways of doing things, and failures are inherent to working with microcontrollers.

I'm going to draw a line in the sand and say that Arduino is excellent for its intended audience: beginners and for prototyping within the limits of its library. If you want to do things that aren't built into the Arduino, however, you should migrate to a more capable set of tools. Don't get me wrong, I wrote the book *An Arduino Workshop* that, along with the associated projects kit (available from *Nuts & Volts*), provides an excellent set of tools for getting started. Once you've exhausted what can

■ FIGURE 1. Breadboarduino on a breadboard.





■ FIGURE 2. SparkFun FT232R breakout.

be done easily, then it is time to move on.

Here, of course, comes the emails. Yes, I know that the stuff underlying the Arduino is all open source and can be rewritten to do anything that any other system for AVR microcontrollers can do. But why bother? There are already perfectly good alternative systems, and I'm going to discuss the free one from Atmel (AVRStudio), along with a couple of other open source applications (WinAVR and AVRdude) that have all the AVR and C programming tools you need for more advanced work.

I've spent some time with this concept in earlier Workshops, but this month we are going to move to more generic AVR development boards by taking the first step of recreating Arduino hardware on a breadboard. We will then write a test program using AVRStudio/WinAVR. Finally, we will build on the last three Workshops and use C# Express to write AVRUP-V1 — an IDE for uploading code to the AVR.

Breadboarduino

Since my surname is Pardue, which has **ardu** (French for steep or difficult — hmmm ...) as does **arduino**, I was tempted to dub this design the Parduino, but humility won me over, so Breadboarduino it is. This hardware system has two main parts: the communications section using the FT232RL and the microcontroller section using an ATmega168.

Using The FTDI FT232R On A Breadboard

In the last few Workshops, we looked at the FTDI FT232R USB Serial Port and learned how to communicate with it using the free C# Express .NET program to build a Simple Terminal and an Arduino Voltmeter. You could get the FT232R portion of the Arduino on a separate PCB, such as the BBUSB (the basis for *The Virtual Serial Port Cookbook* and projects kit available from *Nuts & Volts*). You could — but in an unexpected spasm of non-competitive fervor, I'm going to use a competing product in this workshop: the SparkFun FT232R Breakout board. In fact, the full parts list (Table 1) for this project comes from SparkFun.

Why am I being so generous? Well, mostly because I don't want the support headaches. This

Sch. Part	Description	SparkFun Part #
IC1	ATmega168 with bootloader	DEV-08846
Q1	Crystal 16MHz	COM-00536
S1	Mini Push Button	COM-00097
C1,C2	22pF Capacitor	COM-08571
C3,C4,C5	100nF Capacitor	COM-08375
R1	10k Ohm Resistor	COM-08374
R2,R3,R4,	1K Ohm Resistor	COM-08980
L	Red LED	COM-00533
	FT232R Breakout Board	BOB-00718
	Break Away Male Headers	PRT-00116
	Breadboard	PRT-09567
	Hook-up Wire (22AWG)	PRT-08025

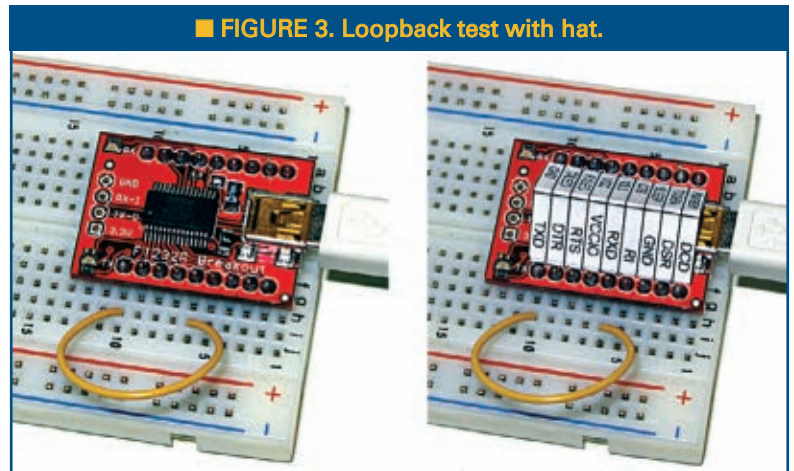
Table 1: Breadboarduino Bill of Materials.

project is hard to get working! In a later Workshop, I intend to port all these concepts to a PCB that will be the basis for future work and a lot easier to use than a breadboard.

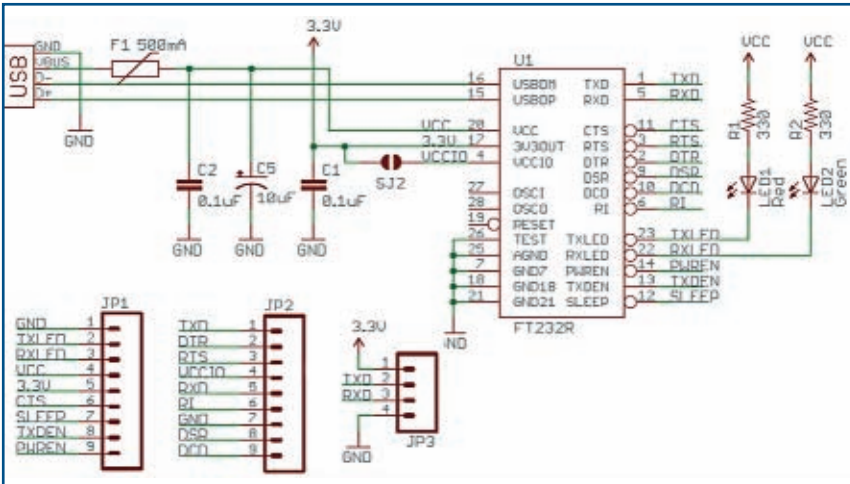
Our first chore will be to put the FT232R board on a breadboard and then test it to make sure the communications side of our system is working. Please note as we progress that things will get increasingly complex and bug-prone, so it will be nice to be able to isolate the sections and test them separately. If you have the final system built and you start seeing flaky stuff (or worse — nothing) on the PC serial monitor side of the cable, then you can pull out the wires, hook in the wire loop, and run the loopback test to make sure the PC and USB sections are working okay.

SparkFun FTDI Breakout

You will need to break off two nine-pin sections of the break-away headers and solder them to the board (long legs down) so that you can plug it into a breadboard. You may notice one tiny problem: The pin labels are on the bottom of the board so when you have it plugged into a



■ FIGURE 3. Loopback test with hat.



■ FIGURE 4. FT232R breakout schematic.

breadboard as shown in **Figure 3**, you can't see which pin goes where. I've sort of solved this by producing a Word document with the table shown in **Figure 3** that when cut out and folded like a tent, has the pins labeled. You can get the Word document in the Workshop21.zip.

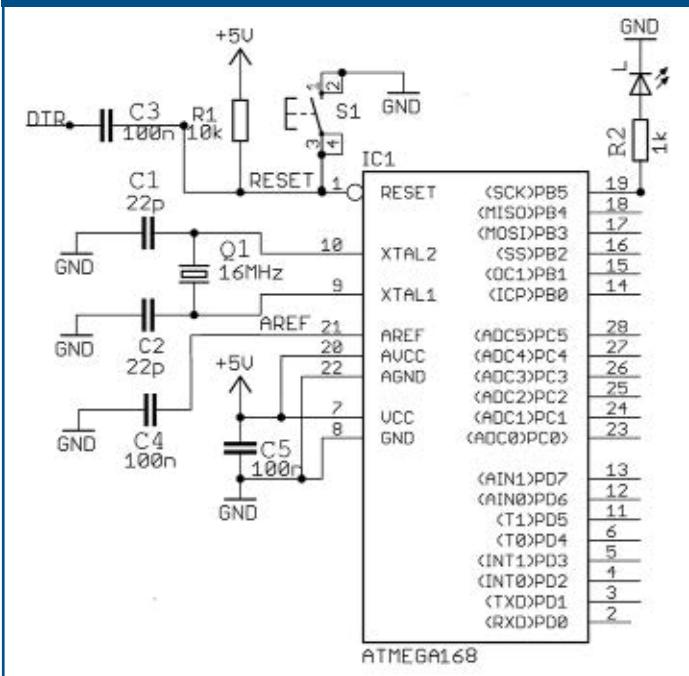
The Loopback Test

After you've got your loopback hardware completed, you can test this with the Simple Terminal we built in Workshops 18 and 19.

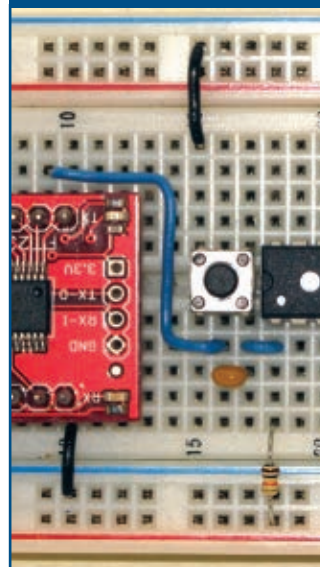
Building The Breadboarduino

We will simplify our lives in this section by leaving off

■ FIGURE 6. Breadboarduino schematic.



■ FIGURE 7. Automatic and manual reset.



confuses a lot of folks, but think about it for a moment. The data being **transmitted** from the PC through to the FT232R is being **received** by the ATmega. The data being received by the PC through the FT232R is being transmitted by the ATmega. **Figure 9** provides an enlargement of the section containing the crystal and the power.

Hello World Program For The Breadboarduino

It is not my intent to scare anyone with a code listing, though I fear that



■ FIGURE 5. Loopback test in the Simple Terminal.

the Arduino power supply section and using only the power from the USB port.

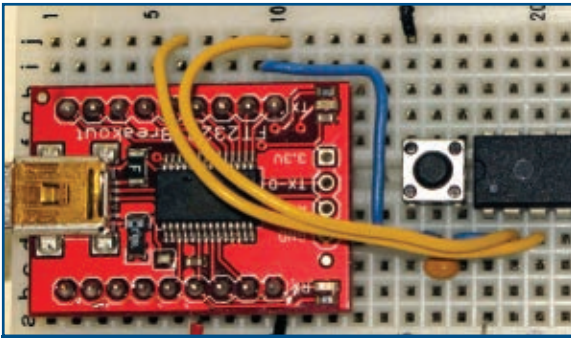
Theoretically, we can take 500 mA from the USB, but there are caveats that cause me to advise using less than 100 mA. This should

be enough to do a Cylon Eyes type project, but probably not enough to run motors.

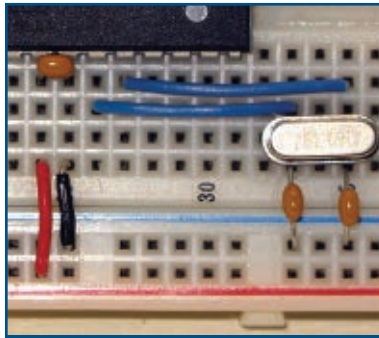
Not all the parts in the figures are exactly like those from SparkFun. I used several color wires and a longer breadboard. Also, if SparkFun has an ATmega328 with a bootloader, get that instead of the ATmega168 and translate where appropriate.

When I built the section shown in **Figure 7**, I had the upper black wire two spaces to the right and nothing worked. Duh, running /RESET to ground tends to create that symptom. I moved it to the position shown and everything worked.

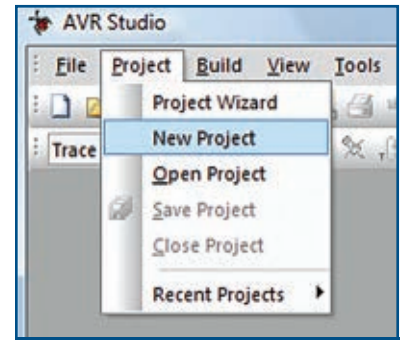
In **Figure 8**, the serial communication wires are in yellow. You may need to put the paper tent label on the FT232R breakout board to see where the Tx and Rx go. REMEMBER: The Tx on the FT232R board goes to the Rx on the ATmega (pin 2), while the Rx on the FT232R goes to the Tx on the ATmega (pin 3). This



■ FIGURE 8. TxD and RxD.



■ FIGURE 9. Crystal and power.



■ FIGURE 10. Select New Project.

those familiar with the Arduino but not yet comfortable with regular C programming will feel like they've been backing down a dark hallway in an old house shining a flashlight in their own eyes when BUMP — they get a look at this code. Relax guys, this isn't a slasher film, and we will — over time — learn what all this means. For now, just type it into the AVRStudio editor [or get the source from Workshop21.zip].

```
/* *****
Breadboarduino_Hello_World Joe Pardue February
10, 2010
***** */
#include <stdio.h>
#include <avr/io.h>

#define FOSC 16000000
#define BAUD 57600
#define MYUBRR FOSC/16/BAUD-1

uint8_t receiveByte( void );
void init();

// From example in avrlibc manual
static int uart_putchar(char c, FILE *stream);
static FILE mystdout = \
_FDEV_SETUP_STREAM(uart_putchar, NULL,
_FDEV_SETUP_WRITE);

int main(void)
{
    uint8_t b;
    uint8_t count = 0;

    init();

    printf("BBArduino_Hello_Test v 005\n");

    while(1)
    {
        b = receiveByte();

        printf("%d", count++);
        printf("You sent: %c\n", b);
    }

    return 0;
}

static int uart_putchar(char c, FILE *stream)
{
    if (c == '\n') uart_putchar
        ('\r', stream);
```

```
// wait for UDR to be clear
loop_until_bit_is_set(UCSR0A, UDRE0);
UDR0 = c; //send the character
return 0;
}

void init()
{
    //USART Baud rate: 57600

    UBRR0H = (MYUBRR) >> 8;
    UBRR0L = MYUBRR;
    UCSRB = (1<<RXEN0) | (1<<TXEN0);

    //set the output stream
    stdout = &mystdout;
}

uint8_t receiveByte( void )
{
    // Wait for data to be received
    while ( !(UCSR0A & (1<<RXC0)) );
    // Get and return received data from buffer
    return UDR0;
}
```

Compiling In AVRStudio

I presume you've downloaded and installed the latest and greatest AVRStudio and WinAVR. If not, get them at:

www.atmel.com/dyn/products/tools_card.asp?tool_id=2725

<http://winavr.sourceforge.net/download.html>

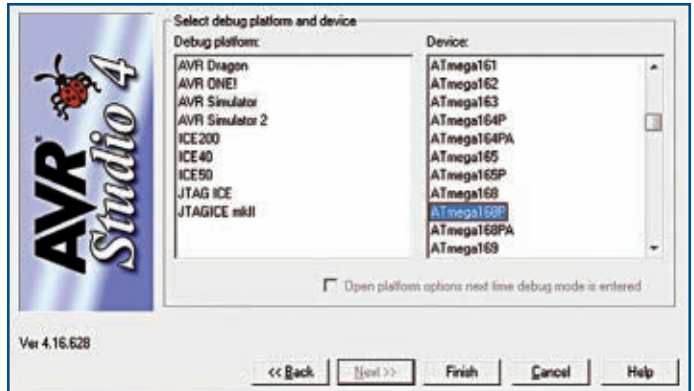
Open AVRStudio and click on the Project\New Project menu item as shown in **Figure 10**. A window will open as shown in **Figure 11**. Highlight 'AVR GCC,' browse to a location for your file, and name the file under 'Project name.' Then click 'Next>>.'

In the next window (shown in **Figure 12**, select the 'Debug platform' AVR Simulator and the Device 'ATmega168P (unless you got the 328); finally, click finish. You can now input the program in the edit window as shown in **Figure 13**.

Click on the 'Build Active Configuration' button as shown in **Figure 14**; if all goes well, you'll get the 'Build succeeded with 0 Warnings...' message.



■ FIGURE 11. Project type and file name.



■ FIGURE 12. Platform and device.

AVRUP V1 — An AVR Program Uploader

The one thing I might miss about the Arduino is how easy it uploads programs to the micro. AVRStudio has AVRProg for uploading, but that thing is so bad that even Atmel no longer supports it. When it works, it is fine, but when there is a problem, it doesn't give many hints as to what might be wrong. The Arduino uploader function is also great when it works, but when there is a problem — it can be down right scary. The little black box at the bottom of the IDE fills with bright red text listing a bunch of cryptic complaints that the novice has no chance of understanding. [I'll assert at this point that if one knows about the underlying avrdude error messages, one is not a novice.] I imagine most novices peek at those bloody looking messages and freak out a bit. One of the goals of AVRUP is to run avrdude in the verbose mode and list everything it has to say in nice black text on a white background, making it easier to get the avrdude manual and figure out what the problem is. [The avrdude manual is in the WinAVR doc directory.]

Back in Workshop 10, I showed how to use avrdude in the Windows command line but personally, I find it can be a PITA to use avrdude casually in Windows because it requires a list of parameters that are daunting to figure

out, type in, and remember the next time you use it. None of these are faults in avrdude — a great program — but for me a more automated process helps a lot (get it right once, then forget how you did it). So, I decided to write a helper program in C#. (Aren't you glad you paid attention to the last three Workshops?)

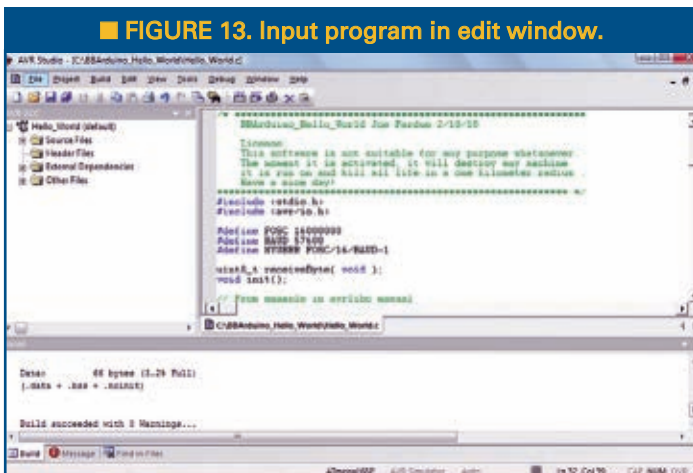
You can get AVRUP V1 as an application and the full source code in Workshop17.zip. I'm not going to discuss that code further here because all the basics were covered in the last three Workshops.

Avrdude On The PC Talks To A Bootloader On The AVR IC

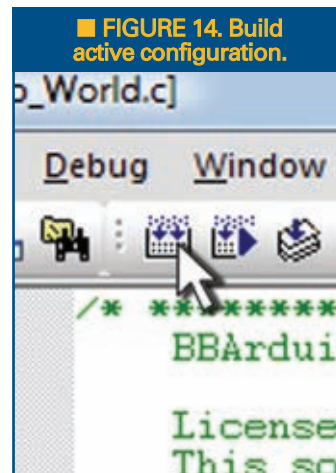
We usually think of a microcontroller as a general-purpose device that has an application program on it defining specifically what it does. An AVR with one application might control the fuel/air mixture in your car's engine. An identical AVR — but with a different application — might control your microwave oven. There are many ways to get an application program loaded onto a microcontroller. One that I like a lot is a bootloader. For this, the AVR memory is divided into two sections: one to hold the bootloader software, and another to hold the application software. We will leave the problem of how to get the bootloader into the AVR for a later article, but this

month we'll purchase an AVR with the bootloader already on it.

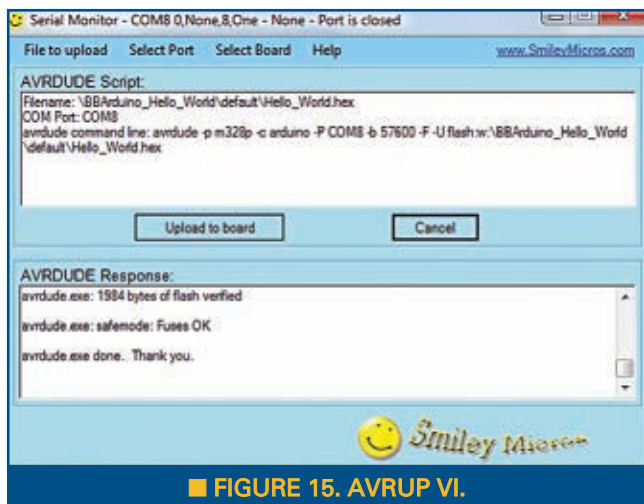
The bootloader on the Arduino is a standard AVR bootloader that starts running when the AVR comes out of reset. It spends a few seconds using the USART serial port to see if something is out there wanting to upload a new application and if not, it gives over control to the resident application program. If



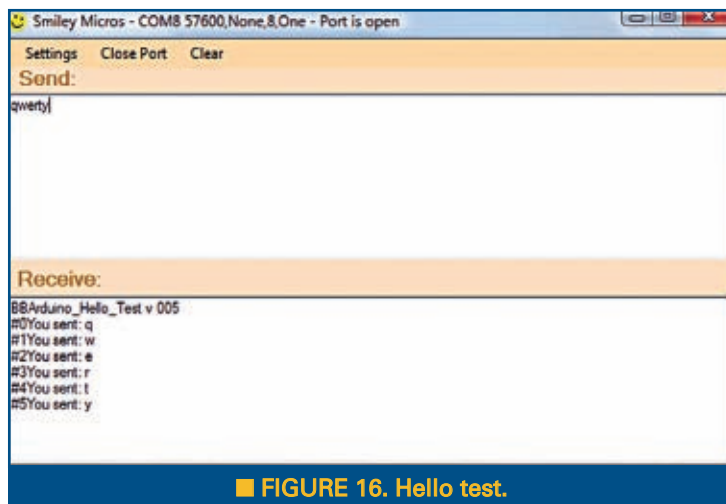
■ FIGURE 13. Input program in edit window.



■ FIGURE 14. Build active configuration.



■ FIGURE 15. AVRUP V1.



■ FIGURE 16. Hello test.

something (an uploader) is on the port and knows how to speak bootloader talk, then the bootloader and the uploader collude to take the application program from the PC and put it in the AVR application memory (overwriting the previous application). The bootloader's final act is to set the AVR to run the application.

Uploading With AVRUP V1

Open AVRUP V1, click on the 'File to upload' menu item, and select the Hello_World.hex file from wherever you stored it. Next, click the 'Select Port' item and select the COM port your Breadboarduino is using (this item should be familiar from the last three Workshops). Next, click on the 'Select Board' item and select the 'ATmega168.xml' file. The 'AVRDUDE Script' window should look like the one in **Figure 15** (except for the m328p which should be m168p). Now, click 'Upload to Board' and watch your Breadboarduino LED flash indicating reset, and note that the red and green LEDs on the SparkFun board twiddle around as avrdude communicates with the bootloader. The 'AVRDUDE Response' textbox fills with lots of information and is followed by 'avrdude.exe done. Thank you.'

Finally, fire up Simple Terminal and test the board as shown in **Figure 16**.

No Seriously ...

What are the chances that you

are going to build all this and have it go as smoothly as indicated by this Workshop? Remember what I said about failing your way to success? Well, all I can say is that I messed up multiple times at every step, but did eventually get it all working. You have all the source materials and should be able to duplicate my success. Next month, we are going to take all we've learned of late and build an even more capable system to support our future learning about the AVR architecture and C programming. **NV**

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■ BY LOUIS E. FRENZEL W5LEF

SHORTWAVE LISTENING: What it is, how to do it, and what to buy.

Listening to the radio has got to be one of the oldest electronic past times there is. Not long after the first radios were put into operation in the early 1900s, there were enthusiasts who put together their own radios from junk parts just to hear what was on and to experience the thrill of tuning in a station from far away ... without wires. Once the vacuum tube came along, radio really took off and stations sprung up around the world. Even with a simple radio, you could hear local and far away stations. Today, there are still many of us who like to do this. The activity is shortwave listening (SWL) and it is both fun and a challenge.

WHAT IS IT?

I was introduced to SWL in my early teens when my father brought home an old Hallicrafters S38B radio he used on board the oil tanker where he was the captain. I strung out some old telephone cable for an antenna and was amazed at what I heard. Foreign broadcasts, amateur radio stations, and all sorts of other strange things. It was fun and an eye opener. It got me interested in ham radio and I managed to get my license in my mid teens. I never tired of listening to whatever was on.

Another early project was my first crystal radio. I had one of the early galena cat's whisker detectors and wound my coil on a cylindrical oatmeal box. I finally got it to work with a long enough antenna, but could only hear local AM stations. It was satisfying, though, to know one could make a radio like this. Later, I built some single tube radios that worked better than I could have imagined. Even today with all the smart phones, digital TVs, and sophisticated ham radio gear, I still find time to scan the radio bands for interesting stations.

SWL is the process of listening to the shortwave bands, generally in the range from 3 MHz to 30 MHz. That includes in all the international broadcast frequencies and the low end ham bands so there is lots of stuff to listen to. While international broadcast stations are the most popular targets, there are other sources like marine, aircraft, military, CB radio, and the occasional

pirate station.

SWL doesn't mean you are restricted to the 3-30 MHz range. AM and FM broadcast stations are also good targets as are digital TV stations. And don't forget all the public service radio stuff you can hear from police, fire, and others on frequencies above 150 MHz. However, you cannot listen to cell phone conversations. It is against the law and radio manufacturers do not include the capability to detect the cellular frequency bands.

One of my all-time favorite listening activities is to see what I can hear on the AM radio band from 530 to 1710 kHz. During the day, all you can hear are local stations, but at night when the sun is no longer present, the AM signals can travel a long way. You can hear stations many miles away thanks to the sky waves that are refracted off the ionosphere. That's what happens to short waves, as well. With multiple skips and hops from the ionosphere to earth and back, a signal can travel literally around the world. I am amazed at what AM stations I can hear.

Listening for FM or TV signals is harder because signals in the 50 to 700 MHz range travel in a straight line so distance is more limited under normal conditions. Reception is also greatly affected by antenna height, but if you can get the right antenna up high and use a rotor, you'll be amazed at what you can find.

If you are interested in SWL, here is a look at some of the radios available these days, and the antennas you will need to get started.

RECEIVERS

A few years back, I decided to get back into SWL. I didn't have a radio so I started to look around. I decided to start with a kit. I found a couple in particular that I liked. One was the Model 1054 from the Tennessee-based ham equipment manufacturer Ten-Tec (www.tentec.com). This is truly a retro kit as it uses one of the oldest circuits around: the regenerative detector.

A regenerative detector is basically an amplifier that also oscillates at whatever frequency it is tuned to. The idea is to tune the amplifier to a signal, then slowly increase the positive feedback to it. This does two things. It increases the gain of the amplifier and narrows the bandwidth. The best setting is just below the point where the circuit breaks into oscillation (wiping out any amplification function).

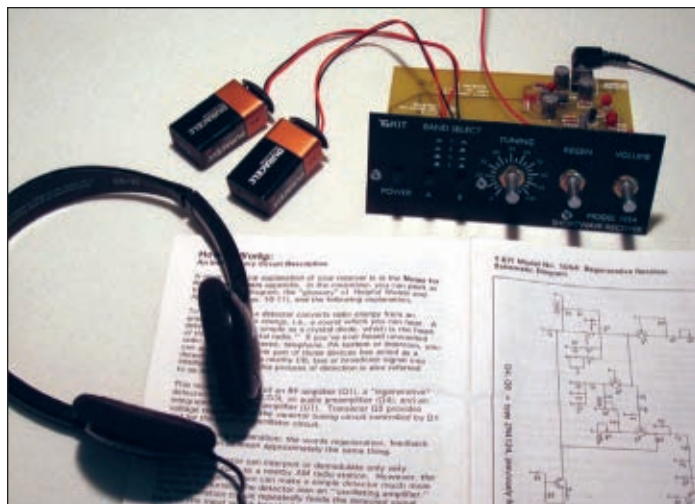
The receiver uses an FET RF amplifier and a couple of FETs in a regenerative oscillator detector. A bipolar stage gives some additional amplification and an IC audio power amplifier drives either a speaker or a headset. The receiver uses a set of pushbutton switches to select a frequency band over the 5.9 to 16.5 MHz range. Power is provided by two nine volt batteries. It took me about two hours to build. **Figure 1** is a photo of my receiver.

The antenna was a 20 foot piece of #22 hookup wire. After I connected the batteries and made the few adjustments required, I got immediate results. My initial tests were during the day, so I didn't find a lot of stations. That night, however, I was amazed at what I could hear. You do have to play around with the tuning, regeneration, and volume controls but it is a process easily learned. For \$39, it's a great experience.

Another kit supplier is Ramsey Electronics (www.ramseyelectronics.com). They have a shortwave kit called the SR2. Other kit choices cover the two-meter ham band, the FM radio band, or the weather band at 162 MHz. They also have an AM aircraft radio kit. Ramsey kits are well done and I have built several of them.

If you decide you want to do more listening, I suggest a compact shortwave radio like the Grundig G4000A in **Figure 2**. It is an AM/FM/SW radio with built-in antenna and LCD screen. The tuning is all digital. It covers all the shortwave bands from 1.6 to 30 MHz, plus AM (530 to 1710 kHz) and FM (88 to 108 MHz). A built-in BFO (beat frequency oscillator) lets you listen to single sideband (SSB) voice and continuous wave (CW or code) signals. Prices for such a sophisticated radio vary from about \$90 to \$200. Eton (www.etoncorp.com) offers this radio and they have a wide range of receivers.

C. Crane is another good choice for shortwave radios. They make perhaps the best AM radio for DXing. The CCRadio-2 Titanium in **Figure 3** is a hot AM radio but it also covers FM, the 162 MHz weather frequencies, plus the popular two-meter ham band. C. Crane also makes a great new SW receiver shown in **Figure 4**. The shortwave model is called the CCRadio-SW. It has full AM and FM coverage, and adds three SW bands from 1.711 MHz to



■ **FIGURE 1.** The Ten-Tec 1054 regenerative shortwave receiver kit.

29.99 MHz. Tuning is digital. Check out the details at www.ccrane.com.

Two places to shop for SW radios are your local RadioShack (www.radioshack.com) and online at Universal Radio (www.universal-radio.com). RadioShack handles the Eton and Grundig radios plus some others. Universal Radio has a huge range of choices. The Icom IC-R75-12 is one of the most popular models they sell. This triple conversion superheterodyne covers SW and frequencies up to 60 MHz (so the six-meter ham band is included). This radio is for the serious SWLer and sells for around \$500.

ENTER SDR

Software-Defined Radios (SDR) are just that — radios that implement radio functions in software that runs on a computer or embedded digital signal processor (DSP). The basic idea of an SDR is that the incoming signal is amplified, then digitized by an analog-to-digital converter (ADC). The resulting stream of digital data representing

■ **FIGURE 2.** The Grundig G4000A portable AM/FM/SW radio.





■ **FIGURE 3.** The C. Crane CCRadio-2 Titanium is optimized for AM band DXing. It has a built-in, twin-coil ferrite antenna. The radio covers the FM band, the ham two-meter band, and the 162 MHz weather band. Price is typically about \$150.

the received signal is then sent to the processor where the filtering and demodulation is done using special software algorithms. The recovered digital signal is then put through a digital-to-analog converter (DAC) and sent for amplification to the speaker or headset.

Until recently, ADCs were not fast enough for RF signals nor were the processors fast enough to process all that digital data in real time. Now, we have both fast ADCs and fast DSPs making SDR a reality. The technique is used almost universally in cell phones but not so much in general-purpose radios. Today, you can buy an SDR SW or ham radio. I hadn't tried one until recently when I decided to buy the RFspace SDR-IQ — a tiny SDR for ham or SW use (www.rfspace.com). It is still expensive (\$500), but its performance competes well against existing analog receivers.

Inside the tiny SDR-IQ in **Figure 5** is an input RF amplifier and some initial LC filters that select signals in one of three ranges: 0 to 5 MHz; 5 MHz to 15 MHz; or 15 MHz to 30 MHz. The signals are then digitized by an

■ **FIGURE 5.** The RFspace SDR-IQ software-defined radio. It essentially covers from zero to 30 MHz. I used an MFJ 16010 antenna tuner to match the 50 ohm input of the receiver to my long wire antenna.



■ **FIGURE 4.** The C. Crane CCRadio-SW has the twin-coil ferrite antenna for AM band listening and full shortwave coverage from 1.7 to 30 MHz. Price is also about \$150.

ADC sampling at a rate of 66.66 MHz. The resulting signal goes to a digital downconverter that effectively selects a 190 kHz chunk of spectrum for processing. The digital signals are then sent to a PC or laptop via the USB port where the Pentium or Athlon processor does the fast Fourier transform (FFT) spectrum analysis, demodulation, and filtering. The USB port powers the entire receiver, as well. You hear the output on your PC speakers or with a headset. Software on the PC shows the spectrum being received and provides on-screen buttons and controls. You literally operate the radio with your mouse.

The screen display in **Figure 6** presents amplitude vs. frequency just like you would see on a spectrum analyzer over a 190 kHz range. You can see all the available signals within that range. Just click on them to hear them. The screen can also implement a waterfall display. This is a vertically scrolling screen (over time) and gives the impression of a waterfall. It's not particularly useful, but cool nonetheless.

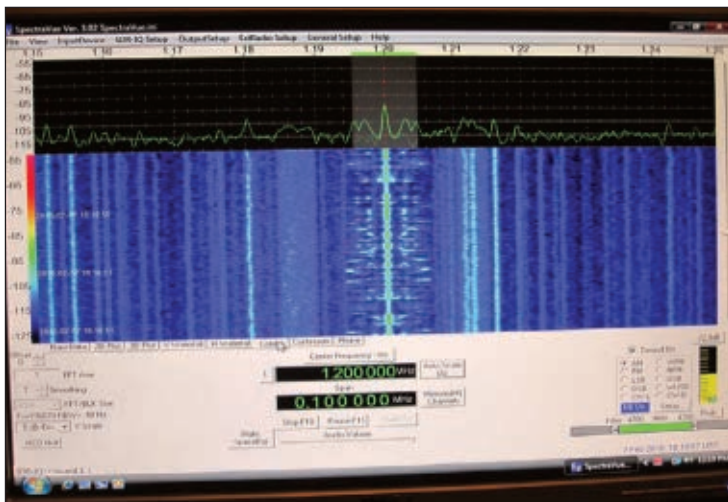
As for performance, it appears to be as good as any other receiver I have used and better than many. Tuning and operating the radio does take some getting used to.

THE CRITICAL ANTENNA

Let me tell you this right up front. You will need a good antenna if you are going to do any serious SWLing, especially DXing. Some radios come with a built-in telescoping whip or ferrite coil antenna. Depending on the receiver, this may be fine. But if you really want to get the farthest and weakest signals, a good outdoor antenna is best. Most of my SWLing is done with a 20-30 ft wire. You will notice significant results if you can string up 50 to 100 feet of wire outside. You can put it in the attic but it won't work too well if you have aluminum shielding for hot summer days.

Most SW radios have a screw or pressure terminal for an external antenna. Some (like the SDR-IQ) only have a BNC 50 ohm connector. I ended up buying a BNC to SO-

■ **FIGURE 6.** The PC screen display for the SDR-IQ is derived from the SpectraVue Software and shows frequency on the horizontal scale and signal amplitude in dBm. The waterfall display is optional.



239 UHF coax connector and an MFJ 16010 antenna tuner (www.mfjenterprises.com). The tuner consists of an L-network with switchable inductor and tunable capacitor. It lets you match the high impedance of a wire antenna to a 50 ohm input on the radio. Adjusting the tuner lets you optimize signal strength on the frequency you are receiving.

If you do not have a good antenna, you may be disappointed at your results which may cause you to give up before you really get to experience the true pleasure of SWLing. If you are going to invest in a radio, spend the few extra bucks to get a great antenna.

HOW TO LISTEN

Night time is the best time for listening. The bands are quieter and the signals travel farther. From my house in the hill country of Texas, I can hear both coasts easily and almost anywhere in the US. Start listening to the 49 meter band around 5.9 MHz and tune up from there. Another good spot is the 31 meter band in the 9.5 MHz range. There are lots of international broadcasts there. The 20 meter ham band in the 14 to 14.3 MHz range is also fertile territory. You will need to use your BFO to hear the CW and SSB voice signals.

Shortwave is AM, so is very susceptible to noise interference. Noise is random amplitude variations. It can come from lightning and other atmospheric effects but most of it is man-made. Auto ignition noise is one source. Fluorescent lights and the new compact fluorescents (CFLs) are horrible offenders. Turn them all off before tuning in. If you are still getting lots of noise, it could be some other appliance. Turn off anything that creates interference. If it has one, use the noise blanker on your radio.

Remember to be patient. You will usually need to listen for a while before the station identifies itself and its location. On the AM band, you may only get the call letters, but just keep listening until you can figure out where the station is located. Lots of SWLers keep a

log recording the time, date, frequency, call letters, and location. Some stations will even QSL. This is where you send a report of reception and signal strength along with the time and date to the particular station. They, in turn, send you a QSL card which is a post card usually with the station call and location acknowledging your report.

SWL can be fun and addictive. Who knows, maybe you'll soon want a ham license so you can talk as well as listen. **NV**

SOURCES

For more in-depth coverage of the SWLing hobby, try these targeted magazines.

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www.grove-ent.com


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www.popular-communications.com

Passport to World Band Radio
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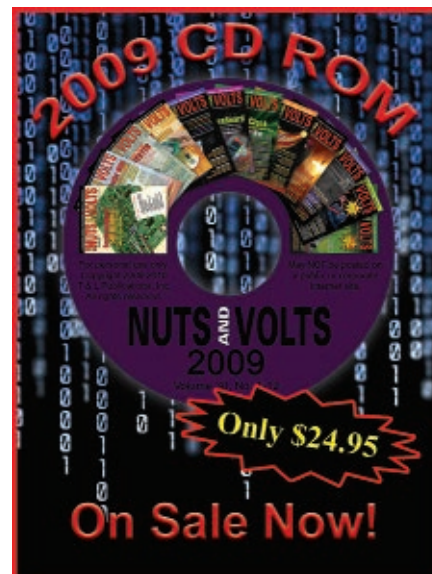
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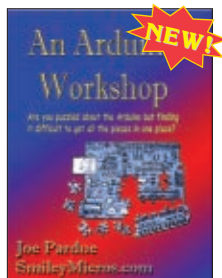


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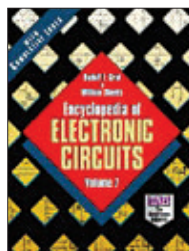
Author Forrest Mims teaches you the basics, takes you on a tour of analog and digital components, explains how they work, and shows you how they are combined for various applications. Includes circuit assembly tips and 100 electronic circuits and projects you can build and test. Forrest M. Mims, III, has written dozens of books, hundreds of articles, invented scientific devices, and loves to share his knowledge with eager students! **\$19.95**



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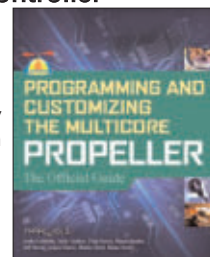
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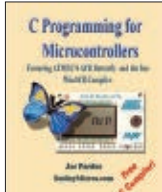
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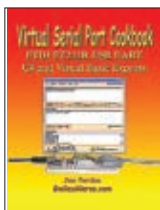


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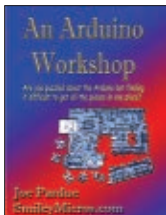
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This is a cookbook for communicating between a PC and a microcontroller using the FTDI FT232R USB UART IC. The book has lots of software and hardware examples. The code is in C# and Visual Basic Express allowing you to build graphical user interfaces and add serial port functions to create communications programs.

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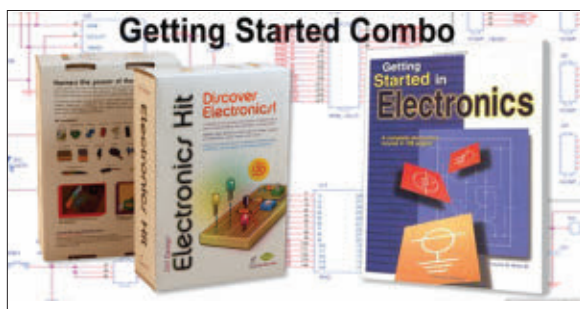
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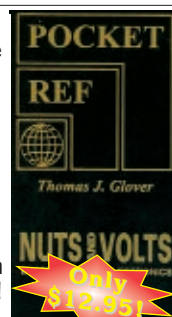
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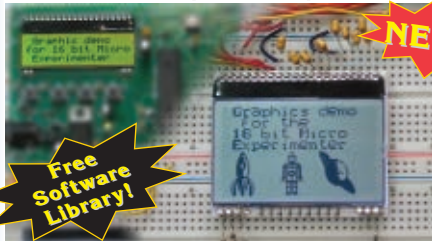
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AVRSimon Kit



As seen on the March 2010 cover

AVRSimon is a do-it-yourself game kit based on the 1978 Milton Bradley flying saucer-shaped game of Simon in which players repeat sequences of light and sound. This fun project is a great way to learn about electronics and soldering, and incorporates basic microcontroller functions such as reading switch inputs, turning LEDs on and off, and generating sounds. Plus, it's fully reprogrammable! For kit details, please visit our webstore.

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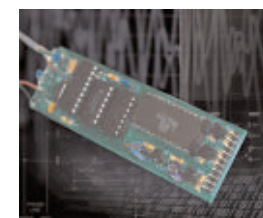
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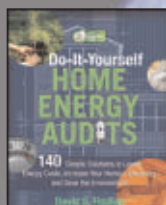
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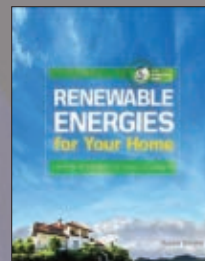
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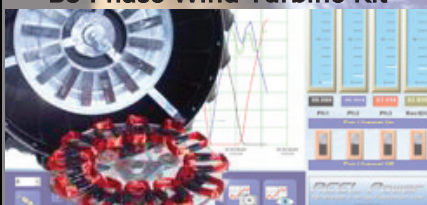
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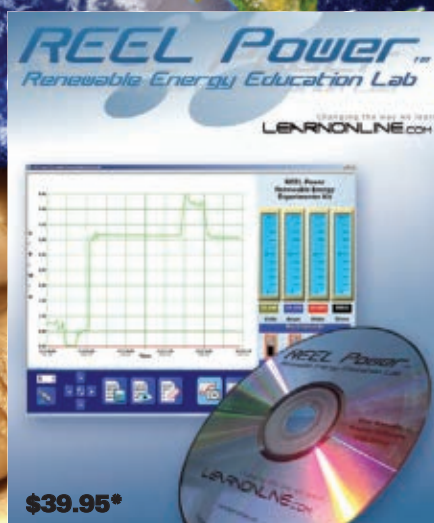
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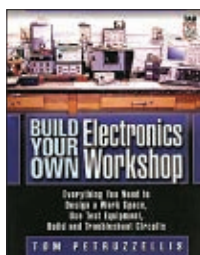
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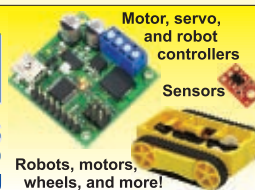


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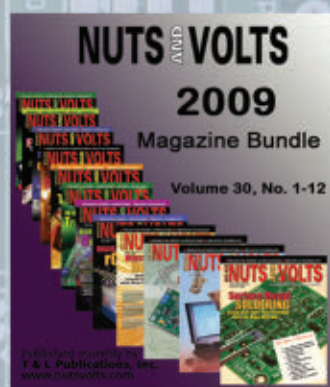
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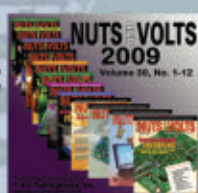
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BECOME A WIZ WITH WIRELESS ETHERNET DEVICES

Put on your pointy hat with the moons and stars on it! This month, we are going to design and construct the first device of the next generation of embedded wireless Ethernet devices. While we're at it, we'll also lay the groundwork for incorporating Microchip's 16-bit line of microcontrollers into future Design Cycle projects.

THEN AND NOW

Five years ago, I introduced the AirDrop series of embedded wireless devices. The AirDrop-P was based on the PIC18LF8722 and used one of the then popular and easy to find 802.11b CompactFlash Ethernet cards. The CompactFlash Ethernet cards used by the AirDrop devices were limited to those that were based on the PRISM chipset. To that end, I devised a PIC firmware driver that supported the PRISM II and PRISM III chipsets. Believe it or not, I am still offering the CompactFlash Ethernet card shown in **Photo 1** to *Nuts & Volts* and *SERVO* readers via the EDTP webstore at www.edtp.com.

Today, there are multiple vendors that offer their own

■ **PHOTO 1.** Although still available from EDTP Electronics, the decreasing availability of this CompactFlash Ethernet card was the toll of the bell for the EDTP AirDrop series of embedded Wi-Fi devices.



particular taste of embedded Wi-Fi. Having written two versions of the AirDrop driver firmware and two versions of EDTP Ethernet MINI TCP/IP code, I tend to lean towards Ethernet hardware that does not require the user (that's you) to write specialized code to drive the embedded Ethernet device. One such device is the new ZeroG ZG2100M Wi-Fi module you see in the raw in **Photo 2**. The ZG2100M mounts just like an IC and contains most everything hardware and firmware that is necessary to put the module on the air. Plus, we don't have to get a Master's Degree in Computer Science to use it.

THE BRAINS OF THE OUTFIT

Despite the ZG2100M's inert intelligence, the ZeroG ZG2100M Wi-Fi Module must be told what to do and when to do it. What better device to be in charge than a 16-bit PIC microcontroller. The 16-bit PIC of choice for this application is the PIC24FJ128GA006. This is the largest baby in the PIC24FJ128GA010 family. Its datasheet tells us that 128 KB of program memory and 8 KB of SRAM are crammed within the area of the PIC24FJ128GA006's 64 pins. Its assets are common all along the many variants of the PIC24FJ128GA010 family. For instance, every PIC24FJ128GA010 family member contains 8K of SRAM regardless of the microcontroller's pin count. The PIC24FJ128GA006's timer count of five is also identical to all of its 16-bit cousins. TIMER1 is a 16-bit timer whose first love is obviously to tick-tock and time events under



■ **PHOTO 2.** The ZeroG ZG2100M Wi-Fi Module is more like an integrated circuit part as it is a DIP (Dual Inline Package) device that is mounted on a set of pads.

program control. However, TIMER1 can also be configured to count synchronously and asynchronously. TIMER1 is very talented as it has the ability to perform gated time accumulation. In addition to gating the incoming time events, TIMER1 can be instructed to prescale the incoming time events in the following increments: 1:1, 1:8, 1:64, and 1:256. An interrupt is available which kicks off on a 16-bit Period register match or the falling edge of the external gate signal. To top off its versatility, TIMER1 can perform its magic even if the CPU sleeps or takes a cigarette break.

Timer modules TIMER2/3 and TIMER4/5 can operate as single 32-bit timers or two independent 16-bit timers per timer module. Like TIMER1, the TIMER2/3 and TIMER4/5 modules can act as 32-bit synchronous counters. My Mom always told me that an apple doesn't fall far from the tree. The 32-bit counter modules are also equipped with gated time accumulation hardware, selectable prescaler settings, and interrupts on 32-bit Period register matches. Not to be outdone, the TIMER2/3 and TIMER4/5 32-bit timer modules can function when the CPU is idle or sleeping. The TIMER5 module has an added feature which allows it to trigger the PIC24FJ128GA006's analog-to-digital converter (ADC) on a comparator match. The PIC's five input capture modules are of particular interest to me. Basically, the input capture module accumulates time over a period of capture time using the services of the PIC's timer bank. The capture time is determined by the rising or falling edge of the input that is applied to the capture module's input pin. In addition, the input capture input signal can be prescaled as 1:1, 1:4, or 1:16.

The capture data is directly related to the speed of the timer that is servicing the capture input module. I recall writing some code that would capture a value on the falling edge of a waveform and swap the capture module's edge detection to capture a second capture value on the rising edge of the same signal. What I ultimately did was capture the period of the incoming waveform. Since the frequency of a signal is the inverse of its period, all I had to do was invert the accumulated period time to determine the frequency of the incoming signal. Yes. All of the PIC24FJ128GA010 microcontrollers have five input capture modules.

In the past, we've done lots of PWM generation using the PIC output compare module. The PIC24FJ128GA006 has five of them. Its output compare module can be programmed to perform a single compare match or a dual compare match. The results of a dual compare match can be either a single output pulse or a continuous output pulse. Of course, the PIC24FJ128GA006's output compare modules can also be shifted into simple PWM mode by twiddling a few bits in the output compare control registers.

Even with the superior data transfer characteristics of a USB portal, it's still good to have a couple of UARTs available to you. The same can be said for SPI portals. In our case, the ZeroG Wi-Fi module feeds from a

PIC24FJ128GA006 SPI portal. If the application requires external memory that is also SPI oriented, there's a portal available on the PIC for both the Wi-Fi module and the external memory module. Recall the first law of embedded computing: "Nothing is free." Thus, if you require the services of both UART1 and the SPI portal 1, you're out of luck as they share the same I/O pins. However, you can employ SPI portal 1 and UART2 as long as you don't need I²C portal 2. I think you get the idea.

The same pin sharing scheme that is implemented for the PIC24FJ128GA006's communications modules is in place for the 16 ADC converter input channels. If you need ADC converter resources that are sharing pins with other PIC24FJ128GA006 modules you need for your application, you can just about always find an available ADC converter channel pin. If the baby of the family has 16 ADC converter inputs, you can bet that the rest of the older children have just as many.

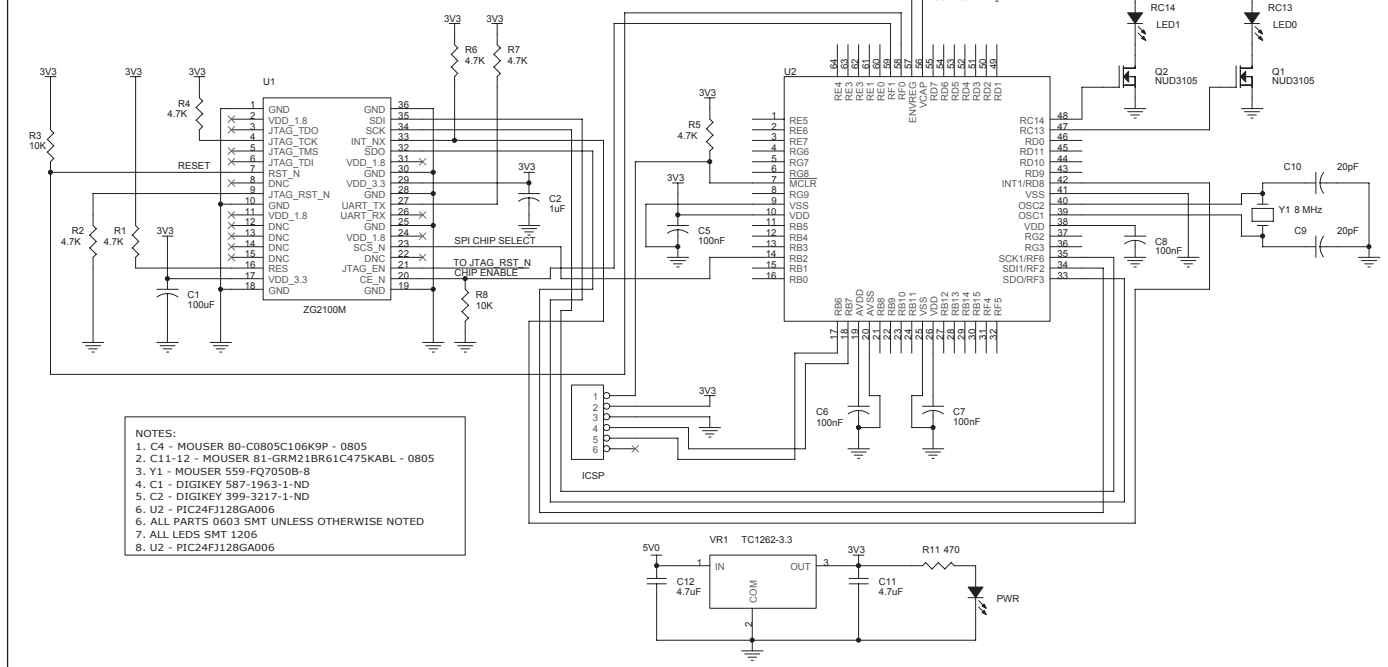
PIC24FJ128GA006 analog capability is represented by a pair of comparators which can be configured in a number of ways. The comparator module's comparator outputs can be programmed to appear on an I/O pin or be used internally without being shown to the outside world. The inputs can be configured to play against each other and produce a preprogrammed comparator output state. For instance, a comparator output can be configured to be logically high when the input at the comparator's V_{IN+} pin is greater than the voltage at the comparator's V_{IN-} input. If we want a logical low for the aforementioned input scheme, we can simply program the comparator to invert its output.

A comparator voltage reference module is also available to the programmer. The comparator reference supply voltage can originate at the PIC24FJ128GA006's V_{DD} , V_{SS} , or external V_{REF+} and V_{REF-} sources. Two ranges of comparator reference voltages with 16 levels each are available to the comparator programmer.

We haven't had a PMP (Parallel Master Port) discussion in Design Cycle yet. That doesn't mean we can't acknowledge its presence. The PIC24FJ128GA006's PMP is a parallel eight-bit I/O module that can be used to communicate with external devices such as LCDs, memory modules, and other microcontrollers. The PMP is comprised of 16 programmable address lines, chip select lines, and read/write/enable strobes. The PMP features I've just enumerated are perfectly suited for reading and writing an EEPROM or 6116 SRAM device. The PIC24FJ128GA006 is also capable of operating in addressable PSP (Parallel Slave Port) mode.

The PIC is capable of clocking at 32 MHz using an external 8 MHz crystal coupled with the PIC24FJ128GA006's 4x PLL. The ZeroG Wi-Fi module requires a power supply voltage between 2.7 and 3.3 volts which falls within the 2.0 volt to 3.6 volt power supply range of the PIC. We'll run our Wi-Fi project using a standard 3.3 volt power supply. Just in case we need to communicate logically with a 5.0 volt device, the PIC's digital pins are all 5.0 volt tolerant. Driving LEDs will not

■ **SCHEMATIC 1.** We only need seven I/O connections between the PIC24FJ128GA006 and the ZeroG ZG2100M Wi-Fi Module to satisfy the needs of the ZG2100M and the TCP/IP stack.



present a problem as the PIC24FJ128GA006 can sink or source 18 mA on all of its I/O pins. Now that you're checked out on the PIC, let's move on and do a walk-around on the ZeroG ZG2100M Wi-Fi Module.

THE ZEROG ZG2100M WI-FI MODULE

Unlike the PRISM-based CompactFlash card you see in **Photo 1**, the ZG2100M is a single-chip device that incorporates 802.11b technology. The ZeroG ZG2100M Wi-Fi Module contains a MAC (Media Access Control) and all of the necessary RF circuitry to go wireless under its shield. To make the ZG2100M programmer's life easier, its driver is in the form of an API (Application Program Interface). Hardware support for security is part of the ZG2100M package supporting WEP, WPA, and WPA2 ciphers. The ZeroG Wi-Fi module will confer with our PIC24FJ128GA006 via an SPI portal with the ZG2100M

participating in the discussion as an SPI slave device.

The Wi-Fi module was designed with eight-bit and 16-bit microcontrollers in mind. At home in any embedded environment, the ZG2100M needs only 250 μ A in sleep mode and hibernates using only 0.1 μ A. The sleep power is managed by the ZG2100M and association is maintained without any need for the PIC24FJ128GA006's resources. This self-governed power control allows the ZeroG module to easily fit into applications that are battery powered. As long as the ZG2100M's CE_N pin is held logically low, the module will manage its power and communicate when necessary, but will not enter hibernate mode. Raising the CE_N pin logically high (+3.3 volts) will force the ZG2100M into hibernation. The ZG2100M is designed to flow between sleep and active states very quickly. The ZG2100M we will be integrating has its antenna etched onto the module's printed circuit board (PCB). If you would like to string your own antenna, you

can purchase the ZG2101M variant which has the capability of integrating an external antenna. Power output at the antenna is typically +10 dBm, which equates to 10 milliwatts. The ZG2100M's power output is programmable beginning at +0 dBm or 1.0 milliwatts.

The Wi-Fi module is capable of

■ **FIGURE 1.** This figure is an excerpt from the ZeroG 802.11 PICTail Plus Daughter Board document. By following this connection path and performing some minimal coding, we instantly become compatible with the TCP/IP stack.

Signal Interface

Function	I/O	PIC18 Pin	PIC24F Pin	Description
CSN	I	RC2	RB2	SPI Chip Select
SCK	I	RC3/SCK	RF6/SCK1	SPI Clock
SDO	O	RC4/SDI	RF7/SDI1	SPI Data Out from ZG2100M
SDI	I	RC5/SDO	RF8/SDO1	SPI Data In to ZG2100M
INT_NX	O	RBOINT0	RE8/INT1	Interrupt Signal to PIC® Device
RST_N	I	RB1	RF0	Reset Signal to ZG2100M
CE_N	I	RB2	RF1	Chip Enable Signal to ZG2100M

■ **SCREENSHOT 1.** I used the excellent CAD capabilities built into ExpressPCB to build the ZG2100M pad farm and no-trace area.

communicating with external devices and programmers that support the JTAG standard. There is also a UART interface that is primarily intended for use in a test environment. Our design will not employ the services of the ZG2100M's JTAG interface and we will not invoke a trace from the ZG2100M's UART. As you can see in **Schematic 1**, the JTAG interface is held at bay by pulling the ZG2100M's JTAG_RST_N and JTAG_EN I/O pins logically low.

To enable us to use the ZG2100M drivers in the Microchip TCP/IP stack, we must connect our PIC24FJ128GA006 to the ZG2100M as directed by **Figure 1**. Well, almost. The connections you see in **Figure 1** are intended for a 100-pin PIC24FJ128GA010.

The ZG2100M's CSN pin acts as the SPI portal chip select and is actually attached to the PIC24FJ128GA006's RB2 I/O pin. Take another look at **Schematic 1** and you'll see that the SPI 1 portal's SCK1 pin actually shares I/O pin RF6 on the PIC24FJ128GA006, as well as the PIC24FJ128GA010. That's where the PIC24FJ128GA006 and PIC24FJ128GA010 SPI I/O pins part ways. The PIC24FJ128GA006's SDI1 and SDO1 SPI I/O pins are shared by the RF2 and RF3 I/O pins, respectively.

The ZG2100M uses an interrupt to trigger data communication event handlers in the PIC24FJ128GA006 firmware. Note that INT1 is actually sharing I/O pin RD8 on the PIC24FJ128GA006. In that I/O pins RF0 and RF1 are used in their native fashion, we simply connect the RF0 and RF1 I/O pins per **Figure 1** just as we did with I/O pin RB2.

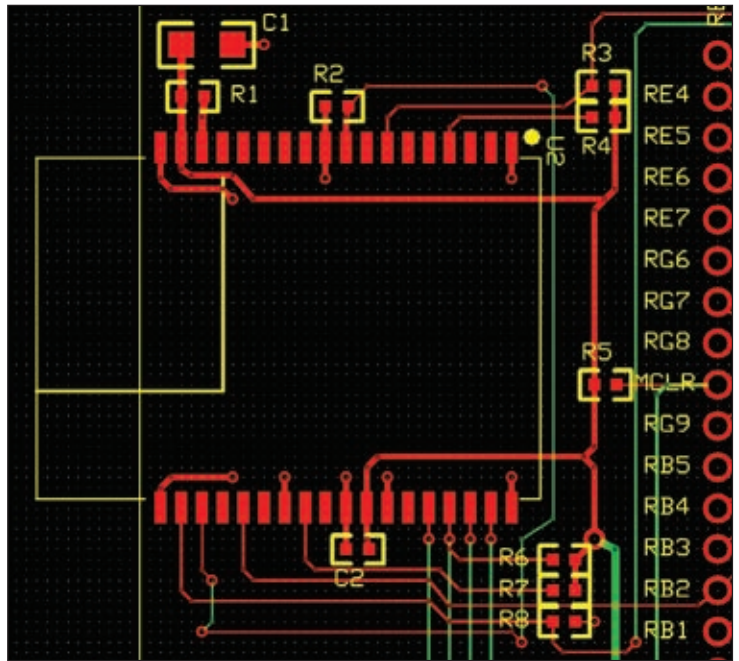
That does it for the PIC24FJ128GA006-to-ZG2100M interface. Believe it or not, that's all you really need to know about the Wi-Fi module if you use the Microchip TCP/IP stack to drive the ZeroG module. With that, let's take a walk around the PIC24FJ128GA006.

PIC24FJ128GA006 ODDS AND ENDS

MCLR pullup resistor R5 is the beginning of a standard PIC24FJ128GA006 ICSP programming/debugging setup with supporting ICSP connections at I/O pins RB6 and RB7. The 100 nF (0.1 μ F) power supply bypass capacitors C5, C6, C7, and C8 are standard and necessary add-ons for any PIC.

The PIC24FJ128GA006 powers its core logic with a 2.5 volt regulated internal power supply. Tying the ENVREG pin logically high enables the

■ **SCREENSHOT 2.** Here's what the ZeroG - PIC24FJ128GA006 Trainer printed circuit board looks like before we add the upper and lower layer ground planes. The PIC24FJ128GA006 I/O pads are on 0.1 inch centers to allow the ZeroG - PIC24FJ128GA006 Trainer to plug into a similar pitched auxiliary board.



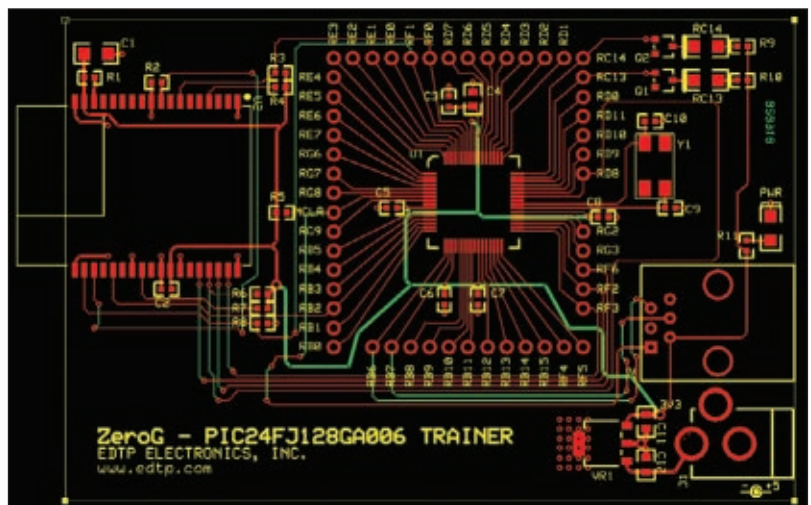
2.5 volt regulator. The PIC's internal 2.5 volt regulator's stability is assured by the presence of C4 – (a 10 μ F ceramic capacitor) and C3 (a 100 nF bypass capacitor) which are both housed in 0805 SMT packages.

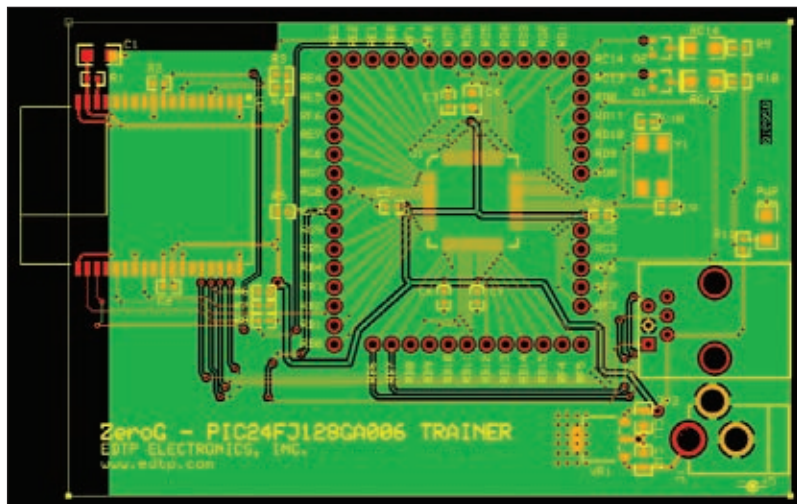
I could have easily left the pair of NUD3105 MOSFET drivers out of this design as the PIC24FJ128GA006 can easily handle driving LED0 and LED1 directly. However, adding Q1 and Q2 allows you to drive inductive and noninductive loads up to 500 mA from the PIC I/O pins if you desire.

I incorporated the TC1262-3.3 into the design to allow you to power the PIC24FJ128GA006 and ZG2100M with a standard 5.0 volt wall wart. I found that I could actually power the circuitry with a 3.3 volt wall wart, as well.

There's no magic at the 8 MHz interface. By designing in an 8 MHz crystal, the PIC24FJ128GA006 can use its 4x PLL to run at 32 MHz if the programmer desires.

Okay. Now that you're checked out on the ZG2100M





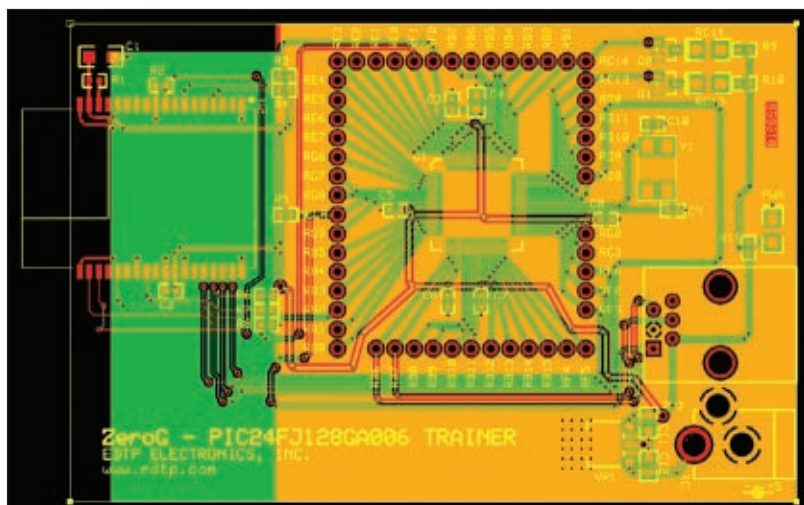
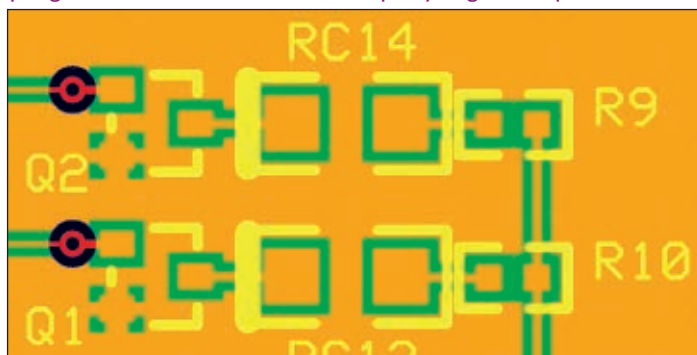
■ **SCREENSHOT 3.** The bottom-layer ground plane has completed the ground path for the ZG2100M and other components. Note that we did not push the bottom-layer ground plane beyond or into the ZG2100M's no-trace zone.

and the PIC24FJ128GA006, let's turn this paper Wi-Fi design into real live Wi-Fi hardware. The build process begins with designing and manufacturing a suitable PCB.

BUILDING A ZEROG - PIC24FJ128GA006 TRAINER

I figured it was time to put a name on this design.

■ **SCREENSHOT 4.** This capture shows the NUD3105 thermal pad connections to the top-layer ground plane. The heatsink tab of voltage regulator VR1 is also programmed to meld with the top-layer ground plane.



With that, behold **Screenshot 1**. Just in case you're wondering why there is a silkscreen legend outside of the PCB boundary to the left, I needed to cordon off and identify the ZG2100M module's no-trace zone. The ZG2100M datasheet recommends that no traces (other than the surface exit traces you see from pins 17 and 18) be placed within the small rectangular area to the upper left of the ZG2100M module pad farm. Eliminating traces in this area will prevent the onboard PCB antenna from being compromised. So, this is a

very important design point and we'll heed the datasheet warning to the letter. Note that only small portions of power and ground exit traces are in the ZG2100M's no-trace zone. The no-trace zone actually extends beyond the PCB boundaries upward 25 mm and to the left an additional 12 mm. To play by the rules, the ZeroG - PIC24FJ128GA006 Trainer will be constructed using a two-sided PCB. When the time comes, we'll bring a bottom-layer ground plane up to the edge of the no-trace box. The bottom-layer ground plane will provide a ground path for all of the vias that are inside the ZG2100M's pad farm. Note that C1 will also benefit from the positioning of the bottom-layer ground plane.

All of the components you see in **Screenshot 1** are packaged in 0603 SMT with the exception of C1 which is a 100 μ F ceramic capacitor packaged in 1206 SMT. Capacitor C2 is a 1.0 μ F ceramic. There are no polarities to worry about for C1 and C2. As you can see in the **Screenshot**, the ZG2100M lays down just like an SMT IC.

Screenshot 2 is a full-board shot of the Trainer. All of the PIC24FJ128GA006's I/O pins are brought out to 0.1 inch centered header holes. The reason for that is to allow the Trainer to be plugged into an auxiliary board of similar pitch. The power connector (J1) is also capable of being pinned from below to provide power for the auxiliary board's devices. In that VR1 will allow +3.3 volts or +5.0 volts to power the Trainer, you can choose your power poison for the auxiliary board without having to worry about getting the proper voltage to the components. To save you some time and effort in your parts procurement process, I have listed the Mouser and Digi-Key part numbers for the large ceramic capacitors and the FOX 8 MHz crystal in a notes box in **Schematic 1**.

■ **SCREENSHOT 5.** The final layer is laid down and I've looked the PCB design over for hours now. It's time to send this baby off to ExpressPCB for manufacture!

We need to lay down top and bottom ground plane layers to complete some of the component's ground paths. The ground planes will also do double duty and act as a heatsink for VR1. Laying down ground planes will also help eliminate unwanted electrical noise. **Screenshot 3** is **Screenshot 2** with a bottom-layer ground plane. As you can see, we brought the bottom-layer ground plane up to the ZG2100M's no-trace zone and no further. All of the vias and holes that were designated to connect electrically to the bottom-layer ground plane are under the bottom-layer ground plane's domain.

All of the holes and vias that are programmed to connect to the bottom-layer ground plane are also programmed to connect electrically to the top-side ground plane. This has been done to accommodate ground connections for top-side components that have been programmed to meld to the plane using a thermal pad. This is the case for Q1 and Q2, and the thermal pad electrical connections can clearly be seen in **Screenshot 4**.

The top-layer ground plane has been applied in **Screenshot 5**. The top-layer ground plane is electrically connected to the bottom-layer ground plane by way of holes and vias that are programmed to electrically connect on both planes. With the addition of our top-layer ground plane, we now have more than adequate heatsinking area for VR1, and the NUD3105s have a ground path. Note that we didn't bring the top-layer ground plane into the ZG2100M's air space.

All that's left to do is check, double check, and triple check our PCB work. Once we're sure we're ready to take the plunge, the ExpressPCB PCB file will be transferred to the ExpressPCB server for entry into their daily production queue.

A COUPLE OF DAYS LATER

I received the PCB you see grinning from edge to edge in **Photo 3**. This is crunch time. Any trace or layer mistakes we made in the initial design run will shine though with some of them having the ability to

release the magic smoke.

I let the cat out of the bag when I told you about being able to power the ZeroG - PIC24FJ128GA006 Trainer with a 3.3 volt wall wart. Anyway, I'm happy to report that the finished board shown in **Photo 4** responded to the MPLAB ICD3 and no magic smoke was released. Just to make sure things were good inside of the PIC24FJ128GA006, I wrote a bit of code to toggle the LEDs attached to Q1 and Q2. A finger on the case of the ZG2100M didn't detect any significant heat signatures and all of the voltage points reported in at +3.3 volts.

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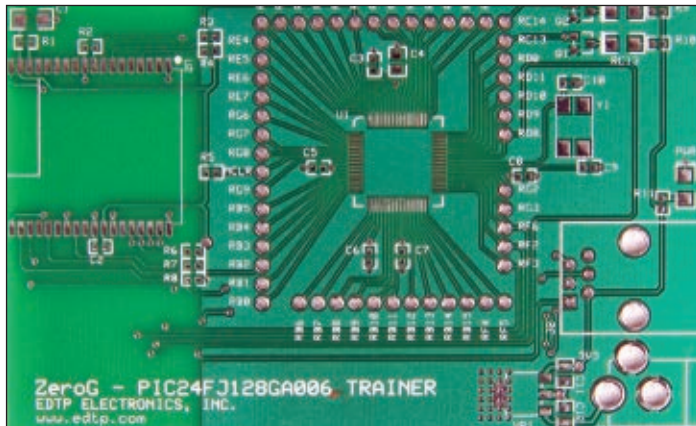
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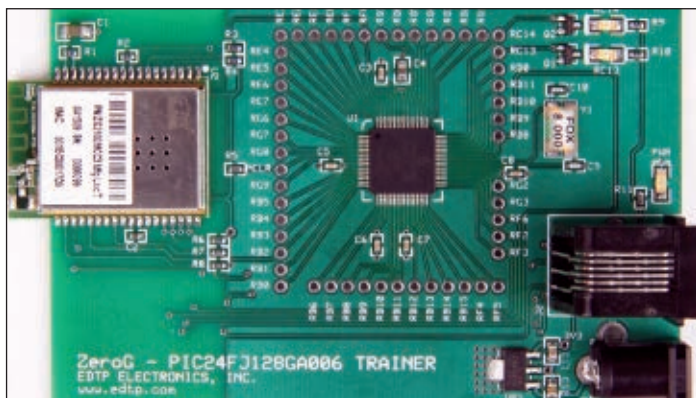
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■ PHOTO 3. This is where any routing mistakes we missed will shine through. If we're lucky, there will be only small errors that we can fix without damaging the board. Otherwise, we learn from our mistakes, correct them, and send for new boards.

IT'S TIME TO MAKE THE DOUGHNUTS

Not really. However, in the next installment of Design Cycle I'll show you how to tailor the Microchip TCP/IP stack to the PIC24FJ128GA006's I/O structure. We also will learn how to define our network to the TCP/IP stack. So, in the meantime get out that soldering iron and get with putting together your ZeroG - PIC24FJ128GA006 Trainer. **NV**



■ PHOTO 4. Here's the fruit of our labor and it works!

Fred Eady can be contacted via email at fred@edtp.com.

SOURCE

Microchip
www.microchip.com
 ZeroG ZG2100M Wi-Fi Module; MPLAB ICD3;
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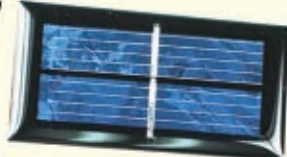


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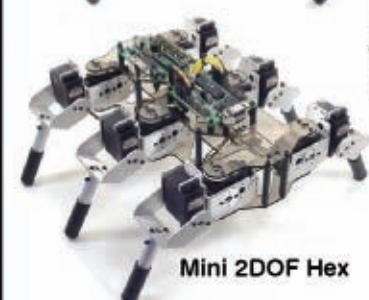
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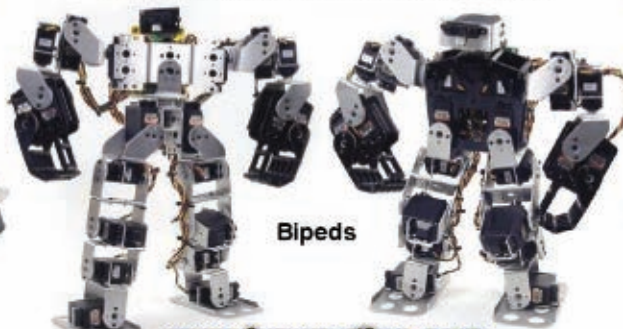
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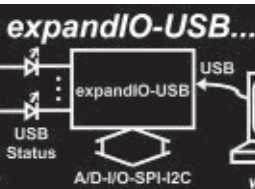
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FEEDBACK continued from page 11

Very sorry to hear about your Mother. Having to deal with sick family members is no picnic.

This also sounds like an interesting and challenging experimental project! Discriminating between sound that indicates a problem and sounds that are environmental, deriving the problem sound's point of origin, moving from the current location to target location, navigating around obstacles between current location and target location — that's a lot of puzzles for an experimental project!

HOWEVER, the key word here is **experimental.** This is just my opinion, but I don't know that I would want to bet someone's life on my ability to program!

If I were going to do a project such as you suggest above, I would do it as a supplement to an existing monitoring solution. I can't imagine how I would feel if some harm came to someone because there was a syntax error in my code that prevented my bot from performing a life saving action!

Some ideas to consider: Firefighters use a motion sensor on the body of the firefighter. If they fail to move (become motionless) for more than a set length of time, an alarm goes off. Details can be found at http://en.wikipedia.org/wiki/PASS_device.

You might be able to make something similar with an accelerometer and a wireless system like a ZigBee unit. The idea would be to make a pendant, belt buckle, or other "wearable" device that is "reset" every time motion is sensed. If no motion is sensed after a preset period of time, an alert could be sent to you to go check to make sure your Mother is okay. The alert could be SMS to your phone for example.

I'm happy to hear the HVAC idea was interesting and I would be very interested to know what you think of the book.

Vern Graner

BROKEN-IN CABLES ... NOT!

Regarding your recent editorial ... those

high-end audio magazines can be a scream. Wonder if the pre-broken-in cables are "oxygen free" or is that last year's scam? My personal favorite is still the \$300 CD demagnetizer that restores the high notes you've been missing from your CDs. CDs, of course, are made of plastic and aluminum — neither of which can be magnetized (as if that made any difference to a digital data file anyway).

Tom Wyckoff

You're right on. I wanted to be much more aggressive in the editorial, but didn't want manufacturers taking out contracts on me. Yes, they're a scream. I'm almost embarrassed to buy a Monster cable of any sort — when I do, it's because of the overall quality, not the vacuum sealed copper conductor or whatever.

I just finished a book with McGraw-Hill on teardowns. You wouldn't believe what's inside of those \$200 power conditioners. Anyway, thanks for the note.

Bryan Bergeron

I ♥ NUTS

Being a long time subscriber, your magazine is great with useful information every month.

Keep up the good work.

John

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>>> QUESTIONS

Using PIC Processor to Generate DTMF

I am an old time subscriber of NV and am looking for info to use PICs to generate DTMF. I am using a PIC 18F2431. Can anyone help? Any assembly code would be of great help.

#4101 Mitch Esken
Peoria, IL

Car Autoranging Ammeter

Looking for a circuit for an autoranging car ammeter. In-line cable shunt output at the battery. Resistor short protection at the battery for a pair of sense wires running to the circuit and meter under the dash. Car battery powered, no microprocessors, low range 0 to 10 amps, high engine start range for starting current, d'Arsonval meter, not digital. Want to see relatively fast amperage changes. Should this go in the negative or positive side of the battery? Accuracy on 0-10 amp range say 10% or better. 20% or better on the engine start range. KISS.

#4102 Lorin
Costa Mesa, CA

Cat RFID

We have four indoor/outdoor cats. My plan is to have each of them implanted with an RFID chip and to have a sensor over the cat door which will read them. The door is already wired to indicate "a cat has gone in" or "a cat has gone out." Now I want to know which cat, and also possibly have the cat door remain locked until a known cat approaches.

I purchased an RFID reader module from Parallax and although this worked okay with the tags supplied, there was no response from the RFID chip borrowed from our friendly vet.

Does anybody have a suggestion for (a) what type of RFID chip to use (there are more than one); and (b) where I can obtain a bare-bones

scanner. I want to capture the tag ID using my own microprocessor when a cat is in range of the sensor.

#4103 Roger Hartop
Falls Church, VA

Flame Rectification

I would like to put together a flame sensor using flame rectification. I am familiar with how it works however, I need some ideas for the sensing electronics. The furnace I have uses a hot surface ignitor.

#4104 Pete Belliveau
Hopkinton, NH

Steampunk Keyboard

I am building a Steampunk keyboard for my own use. I would like to have a small motor spin some gears each time a key is pressed on the computer keyboard. I have not been able to locate an encoder output or an activity monitor that will show key presses. I don't care which keys are being pressed, and the gears spinning are just for show. I would like a hardware solution over a software solution — but a complete *.exe program would be acceptable. (Maybe flashing the scroll lock LED when keyboard activity is being transmitted to the keyboard controller.) Monitoring the data stream for F0(Key up) occurrences would also work.

#4105 Dave Moore
Medina, NY

RF Detector

I'm trying to build a simple RF detector that flashes an LED when it detects a cell phone signal, as well as Wi-Fi. I'm trying to keep it simple to keep costs down. I assume it would be

easiest to use an amplifier, but I'm trying to get a PIC for the detection. The most trouble I am having is on the RF section. Finding the right antenna has been difficult. I've tried using different wire lengths with some detector diodes, but have been having no luck.

#4106 Evan
Fredericksburg, VA

Semi-Automatic Washing Machine Motor Controller

In some semi-automatic machines, there is a controller which controls the forward and reverse direction of the motor. The controller is driven by a small motor and gear arrangement with three options: light, normal, and heavy wash.

Please suggest a simple electronic replacement circuit for the same.

#4107 Ajay Kumar Verma
Patiala, Punjab

Pulse Welding Circuit

I have a transformer type AC/DC TIG welder I would like to add pulsing to the output. Does anybody out there have a circuit diagram so I could add it on?

#4108 Dave Stypula
Johnstown, PA

PIC Micro and USB

Long ago, I was competent programming in Microsoft QBasic. Now most/all articles use either assembly or C. Do any of the popular microcontrollers program in some version of Basic? I am not into a "C" level of retraining at age 67. Suggestions ...

I'm looking for serious how-to articles — or worst case — books on using some microcontroller that

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#4109

Bill
via email

DC Motors

How does an interpole winding work in a DC motor?

#41010

Michael Coy
Indianapolis, IA

>>> ANSWERS

[#12092 - December 2009]

Computer Standby

I read the Oct '09 article on "The Green Standby" and was wondering if there is a circuit that would turn on or off all the cube powered equipment attached to my computer when it first gets turned on.

Sears sells a device to do exactly what you need for \$19.99. It's called the Craftsman 24031 Auto Switch. You can buy it at Sears.com, or see www.kaboodle.com/reviews/craftsman-24031-auto-switch-at-sears.com for a review and more information. That will be cheaper than the parts needed to build one by hand.

It is made to automatically cut off a dust collector when you turn off your saw. It runs on 120 VAC, uses a standard plug, and has one master and two accessory outlets. Plug your computer into the outlet labeled "Power Tool" and an outlet strip with the cube or other items into either of the accessory outlets.

Kirk Ellis
Pikeville, NC

[#12093 - December 2009]

H-bridge/Relay for Trolling Motor

I'm designing a dual 12V, 50-pound-thrust trolling motor assembly for a small boat. It will run from 24V to achieve brief bursts of relatively high speeds on an engine-restricted local

lake. I'll be using two independent PICAXE controllers for direction and speed control for each motor. Should I use a semiconductor H-bridge or a relay to switch directions on the motors? I'm leaning heavily towards a relay for simplicity. Also, I need a part or circuit that can be driven with the PICAXE-level PWM signal and control the 12V motor (running from 24V) with an unknown surge current level (possibly over 100 amps per motor).

Since you are using PWM, the easiest approach is to go with a full H-bridge and N-Channel MOSFETs throughout. An excellent application note for a low voltage H-bridge motor drive is the Motorola Semi AN1319. It was written to show the application of their MDC1000A — a MOS turn-off device. It was designed for 24-48 volt applications. Although there are now faster devices available from Microchip and other vendors, it shows a good implementation of a high-side N-Channel MOSFET with a unique charge pump. The switching signals are transmitted through current sources which are supply-voltage independent and fast (no opto-coupler).

The high-side MOSFET is driven through another current source which allows fine-tuning the turn-on characteristic. Turn-off is accomplished with the MDC1000A (which can be replaced by two transistors, two resistors, and two diodes).

Walter Heissenberger
Hancock, NH

[#12094 - December 2009]

Voice Phrase Toy

I want to embed four different short voice phrases that I'll record beforehand and load on to a device that plays them from pushing one of four buttons out of an eight ohm

speaker. Wondering if anyone has a schematic or something on the code to point me in the right direction.

#1 The ISD ChipCorder line of devices should fit your needs nicely.

These devices come in a variety of configurations, need few external components, and generally have an eight-ohm speaker amplifier built right in. Most, though not all, of these devices are in stock at Digi-Key.

You can see the product overview at this address:

www.nuvoton.com/hq/enu/ProductAndSales/ProductLines/ConsumerElectronics/IC/ISDVoice/IC/ISDChipCorder/.

Nick Hulst
Cedar Rapids, IA

#2 One thought is to look at the greeting cards that can record a phrase and then play it back when the receiver of the card opens it.

The card I had cost \$7. Maybe four cheaper ones? You can easily rip the board out of the cards. Almost everything you need is there — batteries, microphone, and speaker. Mine had three batteries hardwired in; no idea how long they'd last though.

You can buy the raw recording/playback systems. Amazon has them. Do a search on "recordable greeting card." They had a set of 40 of them for \$165 or a set of two for \$26. Possibly cheaper to find the cards on sale at your local drug store.

Pete Lunt
Fairfax, VA

#3 AllElectronics.com sells a little movie promo toy called the Saw 3 Digital Voice Recorder for a mere \$2. It can be taken apart to do exactly what you want. The (up to) 30 second recorded message is in volatile memory, I think, so you may

need to add a super capacitor to hold your recordings when changing batteries. I've had one that has held a message for over six months and the AAA batteries are still fine. Here is the link. I hope this does the trick for you. www.allelectronics.com/make-a-store/item/SAW-3/SAW-3-DIGITAL-VOICE-RECORDER/1.html.

**Andrew Eliason
Mashpee, MA**

[#12095 - December 2009] Phone to PC

I would like to connect the line-out signal from my PC sound card to the handset jack of my office phone in order to record voice mail greetings that I have composed on a PC. Can a direct connection be made to the microphone terminals of the jack, or is an interface circuit required to match the signals?

Figure 1 shows a practical circuit for a PC to Phone bi-directional interface circuit. Unfortunately, this circuit is required. DC levels are present on the MIC input to supply the electret microphone's FET, and the output level is considerably higher than needed – resulting in an overload at the input. R4, R7, R8 may not be needed; however, I have seen some amplifiers become unstable if driven from a considerably lower input impedance than expected. The values of R3 and R6 can be adjusted to fine-tune the audio levels.

**Walter Heissenberger
Hancock, NH**

[#12096 - December 2009] Transconductance Amp

Recently, the OP-27 op-amp has come up in some suggested preamps for VLF reception. I can find no cross-reference to this particular device, but it seems to have the same footprint as the old 741 and the newer CA3140. I would like to use this as a preamplifier for a low impedance untuned loop antenna for VLF. Since it will operate at low impedance in and out, does this come into the category of a "transconductance" amp as opposed to a voltage amplifier?

The OP27 is a low noise, low offset precision op-amp made by Texas Instruments and Analog. Primarily intended for professional audio and instrumentation applications, it has a standard op-amp configuration, inverting and non-inverting high resistance input, and low impedance (70 ohm) output. It is a voltage-to-voltage device. A change of 1 mV at the input produces a change of 1 mV x open loop gain (1.8 million) at the output, within compliance range (this would be 1,800V – in practice, it will go close to one of the supply rails). Negative feedback stabilizes the amplifier and makes the arrangement very accurate. The OP27 can easily drive 600 ohm loads which should be more than adequate. It is an excellent choice for this application. A transconductance amplifier is a voltage-to-current device. The CA3080 (obsolete), LM13700, and OPA860 are some commercially available devices. Trans-

conductance is defined as: $gm = \frac{\Delta I_{out}}{\Delta V_{in}}$
The transconductance amplifier can be thought of as a voltage controlled current source (VCCS) and is often modeled as such. It is used for applications such as voltage controlled resistors, voltage controlled amplifiers, multipliers, and voltage controlled filters.

**Walter Heissenberger
Hancock, NH**

[#12097 - December 2009] Lithium Polymer Batteries

It seems that the LiPo battery is all the rage these days but – outside of voltage and maybe current hour ratings – there are a number of other trailing numbers and letters in the specs that are unknown to the average person. I've even heard of some exploding. Can someone enlighten us a bit?

LIPO batteries come in 3.7V cells that are stacked in series for 7.4, 11.1, 14.8V, or parallel for more energy (800 mAh, 2,200 mAh, 4,000 mAh, etc). Usually the number of cells is marked as 2S-2 cells (7.4V) or 3S-3 cells (11.1V), but upon the rated voltage anyone can detect the number of cells. A cell is one battery that can be produced with the LI-Po technology.

There is another mark that says 15C or 25C or 35C or so. This I believe is the max current rate (you need to check further to confirm this) and overreaching it practically destroys the battery, so buy the appropriate current draw rating battery or above for your battery to last.

LiPo batteries do explode, as you can see on YouTube. Sometimes at the end of their life they inflate – a sign it should be discarded. Throughout its lifetime, a LiPo battery needs to be handled with care – either when running or charging – because as soon as the inside chemicals reach the environment, they will burn violently. Remember Dell's recall of batteries about 3 years ago? Batteries catching fire, laptops igniting ... this was real scary.

**Alexandru Vatamanu
via email**

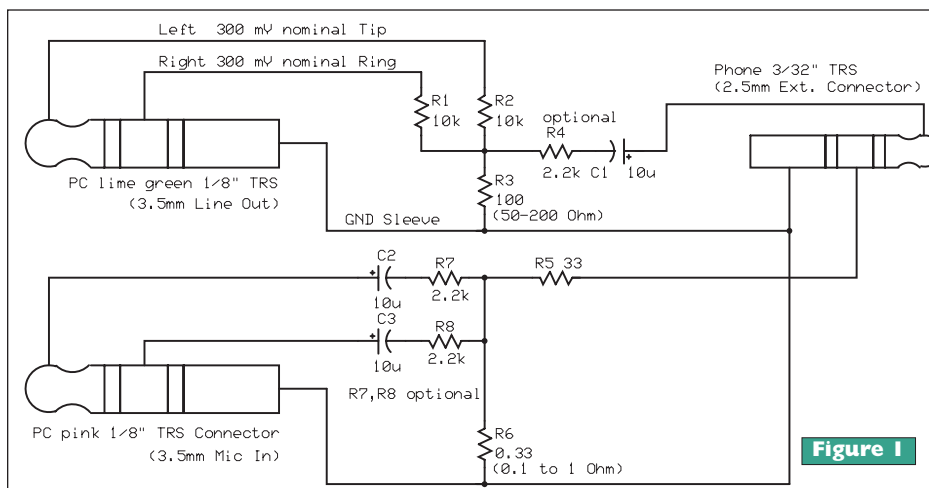


Figure 1



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Full specifications at

www.CircuitSpecialists.com/Aardvark

The Aardvark Wireless Inspection Camera is the only dual camera video borescope on the market today. With both a 17mm camera head that includes three attachable accessories and a 9mm camera head for tighter locations. Both cameras are mounted on 3ft flexible shafts. The flexible shaft makes the Aardvark great for inspecting hard to reach or confined areas like sink drains, AC Vents, engine compartments or anywhere space is limited. The Aardvark II comes with with a 3.5 inch color LCD monitor. The monitor is wireless and may be separated from the main unit for ease of operation. Still pictures or video can also be recorded and stored on a 2GB MicroSD card (included). The Aardvark's monitor also has connections for composite video output for a larger monitor/recorder and USB interface for computer connection. Also included is an AC adapter/charger, video cable and USB cable. Optional 3 ft flexible extensions are available to extend the Aardvark's reach (Up to 5 may be added for a total reach of 18 feet!).



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Coupling	AC/DC/GND		
Vertical resolution	8 Bit		9 Bit
Gain Range	10mV-5V, 9 Steps		10mV-10V, 10Steps
DC Accuracy	+/- 3%		
Timebase Range	4ns - 1h 38 Steps		2ns-1h, 39 Steps
Vertical adjustable	Yes		
Input protection	Diode clamping		
X-Y	Yes		
Autoset	Yes (30Hz~40MHz)	Yes (30Hz to 60MHz)	Yes (30Hz to 200MHz)
EXT. input	Yes		
Trigger Mode	Auto / Normal / Single		
Trigger Slope	+/-		
Trigger Level Adj.	Yes		
Trigger Type	Rising edge / Falling Edge		
Trigger Source	Ch1 / Ch2 / EXT		
Pre/Post trigger	0-100%		
Buffer size	10K-32K per ch		10K-512KB per ch
Shot Bandwidth	DC to 40MHz	DC to 60MHz	100MHz
Max Sample Rate	100MS/s	150MS/s	250MS/s
Sampling Selection	Yes		
Waveform Display	port/line, waveform average, persistence, intensity		
Network	open / close		
Vertical Mode	Ch1, Ch2, Dual, Add		
Cursor/Measurement	Yes		
Spectrum Analyzer			
Channels	2 Channels		
Math	FFT, addition, subtraction, multiplication, division.		
Bandwidth	40 MHz	60 MHz	200 MHz
Cursor	Frequency, Voltage		
Data Samples	10K-32K/Ch		10K-1M/Ch

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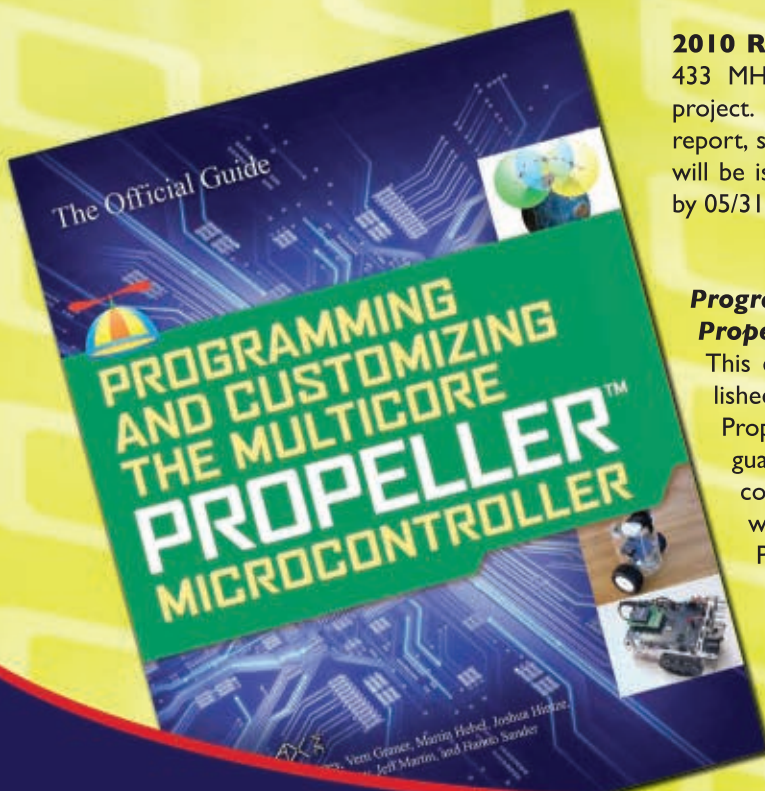


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